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The fee for this course will be $75.00. For application, write to Dr. Arthur H. Wuehrmann, Director of Graduate and Postgraduate Studies, Tufts College Dental School, 136 Harrison Avenue, Boston 11, Massachusetts.

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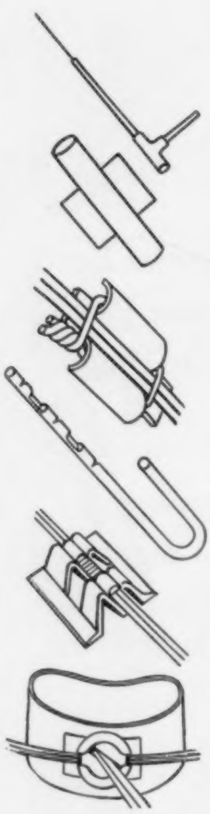

American Journal
of
ORTHODONTICS

Vol. 36 September, 1950 No. 9

Original Articles

SIMPLICITY IN ORTHODONTIC CONCEPT AND TREATMENT

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ORTHODONTICS is predicated on the infinite variations of the human organism and the uniqueness of the individual.

These two fundamental facts constitute the only basis on which it is possible to conceive of a system of orthodontics of the future which will be comprehensive enough to be universal in its application, and in which we may all eventually hope to find a common ground of understanding.

In order to have a truly comprehensive idea of what the field of orthodontics covers, the factors involved, and their relation to each other, it is helpful, if not absolutely necessary, to have constantly in mind some sort of panoramic sketch or working model of the whole field of operations in order to avoid the fatal mistake of losing sight of our main concepts and objectives in a maze of details of secondary importance.

Fig. 1 is a schematic outline which I presented in a previous paper, and which I have found useful in my own efforts to allocate facts to their proper places and relations to a comprehensive whole.

A few concrete examples of extremes of variation are usually helpful in dispelling any tendency toward stuffiness of mind in approaching clinical problems.

On a purely scientific basis, the practice of orthodontics is, and always will be, completely impossible for the simple reason that infinite variation, whether in orthodontics or anything else, cannot conform to any obviously futile attempts at exactness of formulation which are based on hopelessly inadequate statistical, quantitative, dimensional, or orientative plans which leave out of consideration functional and volitional elements which are infinitely more difficult of exact scientific calculation. Perhaps the first and most important step in orthodontic understanding is to recognize this basic truth and not be misled by narrow-minded "systems" which are not only out of harmony with these basic facts, but in some cases openly trample on some of the most valued scientific principles which we have already so laboriously discovered.

Our scientific ignorance, however, should not disturb our confidence in our own abilities to cope successfully with our clinical problems. We are, fortunately, endowed by Nature with certain inherent talents which enable us to perform, quite easily and naturally, infinitely more difficult functions of life than those we will ever be faced with in orthodontics. These talents are developed in us by a method which is so simple, natural, and direct that it does not need any formal education, or even the conscious awareness of any analytical thinking. ***This is the saving grace of orthodontics*** and the reason for the optimistic title of this paper. Nature constantly dangles before us a perfect example of the exact method by which this is done.

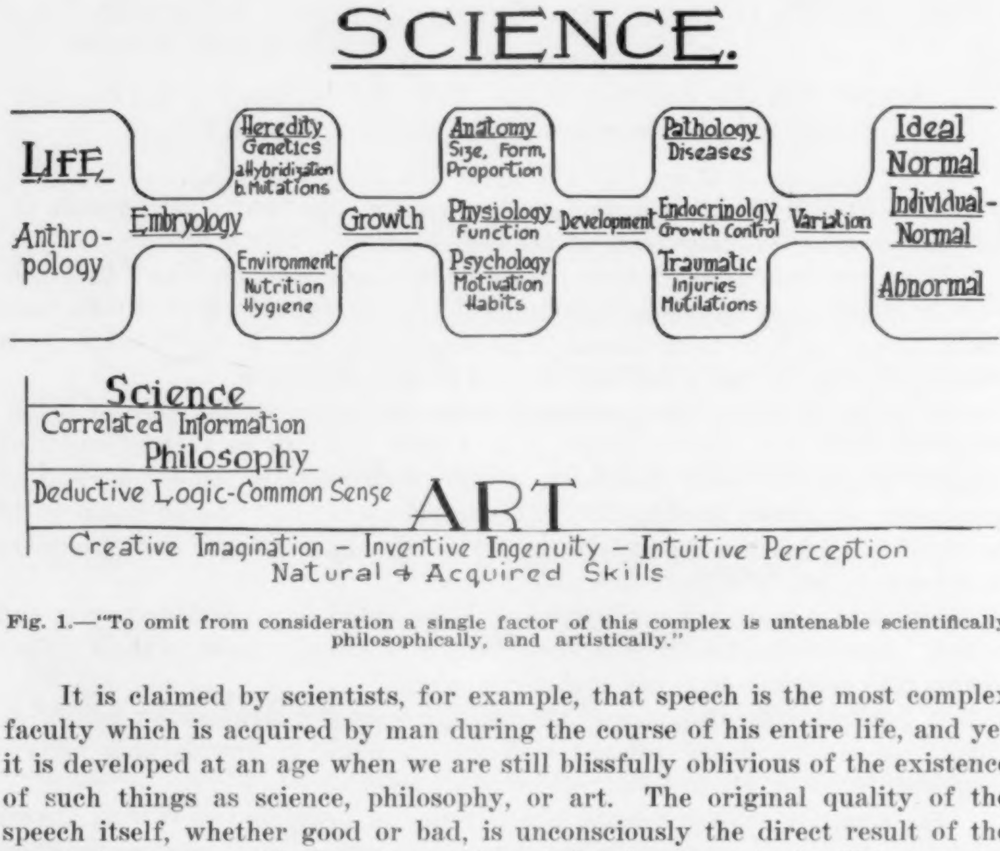


Fig. 1.—"To omit from consideration a single factor of this complex is untenable scientifically, philosophically, and artistically."

It is claimed by scientists, for example, that speech is the most complex faculty which is acquired by man during the course of his entire life, and yet it is developed at an age when we are still blissfully oblivious of the existence of such things as science, philosophy, or art. The original quality of the speech itself, whether good or bad, is unconsciously the direct result of the personal contacts with those from whom it has been acquired. This contains an element of vital importance to students of orthodontics.

Acquired skills are initially the result of *exercise* and *imitation* (psychologists differ in the order of the two), developed later by original thinking and experimentation, and carried to varying degrees of individual efficiency by constant study and incessant practice.

This is the basic pattern of all human development, and the open road to orthodontic progress.

The late Professor Whitehead of Harvard once defined an ideal college professor as "an ignorant man thinking."

The orthodontic problem starts at the moment of conception because the individual can only be the direct result of his own peculiar heredity and environment. He is, therefore, inescapably unique within a very broad range of quite natural, but unpredictable, variation. Under heredity, hybridization is probably the most important single factor in producing orthodontic problems, because genetic patterns are the direct product of the laws of genetics with results which, although in most cases quite normal and natural, are often unfortunately most unsatisfactory for some specific individuals.

A. B. C. D. E. F.

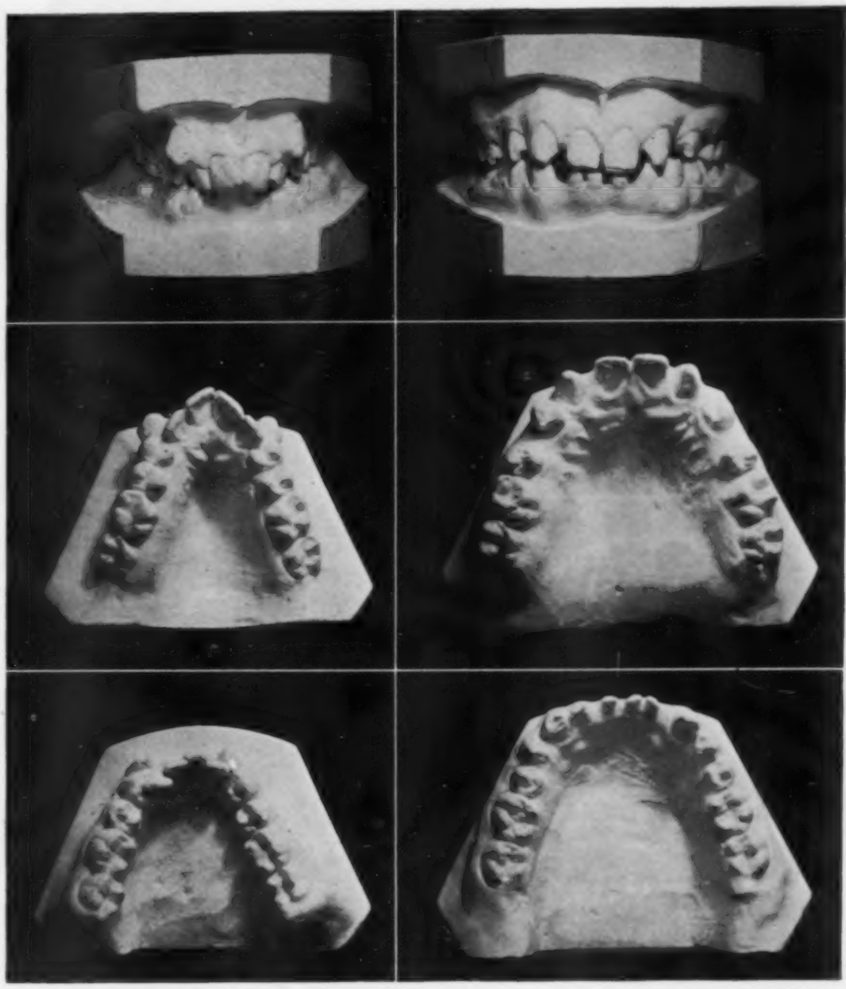


Fig. 2.—*A*, *B*, *C*, *D*, *E*, and *F*, Comparisons in the sizes, numbers, and proportion of the teeth and bony development between two perfectly healthy superior types of individuals.

A glance at our illustrated magazines or society columns presents problems in the question of matrimonial selectivity which are quite beyond the scope of any mere orthodontist to fathom or do anything about anyway.

Fig. 2 shows two comparative examples of extremes of variation in very superior types of individuals.

Fig. 3 is another set of samples of genetic variation, the interesting feature about these comparative models being that they were taken from a full brother and sister.

A.

B.

C.

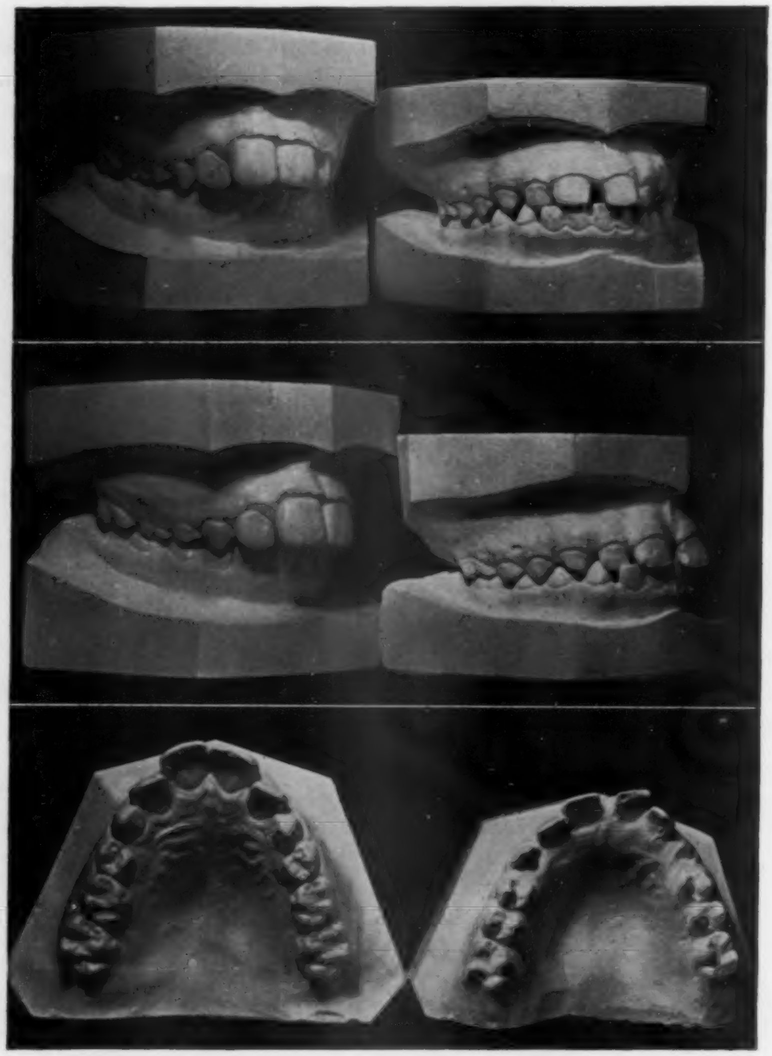


Fig. 3.—*A*, *B*, and *C*, Comparisons in the sizes and proportion of the teeth of a full brother and sister.

As according to the laws of genetics there are some thousands of genes from each of the parents, and these are capable of producing some untold millions of combinations, the individual variations are quite in accordance with the scientific facts responsible for them. It is obvious that the statistical quantitative, dimensional or orientative methods of evaluating the individual may lead to some very erroneous conclusions. At the best they are purely relative. It has been said that "the sciences have a tendency to take us away from the individual and the actual, into a world of increasingly mathematical

abstractions which often issue into momentous conclusions of no practical importance."

On the other hand, "The origin of Art lies in the power of forming images —it takes us directly to the unique person and unique fact. Imagination precedes thought, and is necessary to it; the aesthetic or image forming activity of the mind if prior to the logical concept forming activity. Man is an artist as soon as he imagines, and long before he reasons."

A true artist, which every orthodontist should be, cannot do more than view the entire orthodontic panorama, with its infinite variations and complexities, from the viewpoint of an impressionist and work for results which will combine concepts, objectives, and techniques in terms of harmonious total effects.

Pascal has said that first principles are too self-evident for some people!

The object of science is to see things as they are, to draw conclusions from facts, and to experiment freely in order to discover the truth.

During orthodontics' short, and somewhat stormy, career a considerable amount of experimenting has already been indulged in, as a result of which some fairly satisfactory results have been obtained by various and widely divergent methods of procedure. Some sound scientific principles of universal application are likewise beginning to make themselves clearly evident. An analysis of these results, the methods employed in obtaining them, together with a study of the fundamental principles which underlie them, should lead to a better understanding between orthodontists. This is not going to be easy!

Broadly speaking, the purpose of orthodontics is to improve the functional efficiency and esthetic harmony of the teeth and surrounding tissue—to convert "unsatisfactory" dental occlusions into more "satisfactory" ones.

The word "satisfactory" is used advisedly because it contains a combination of essentially desirable qualities which are in perfect harmony with infinite variation. A "satisfactory" dental occlusion consists of one in which there is a balanced proportion of tooth substance to bony development, an efficient functional excursion of the mandible, and a pleasing facial appearance. These attributes can be termed structural balance, functional efficiency, and esthetic harmony. All unsatisfactory conditions can be simply and clearly classified under one or more of these headings.

A *qualitative classification* is the only one that is applicable to infinite variation. It is possible that the time has arrived when a classification on this basis should be adopted generally rather than to continue to hang to classifications which contain tacit implications of definite anatomic relations which are purely relative and, to the uninitiated in particular, are exceedingly misleading.

The opinion as to what constitutes the most satisfactory occlusion for any specific individual, combining the three qualifications, structural balance, functional efficiency, and esthetic harmony, is an artistic equation of the most subtle order, and *is inescapably a matter of personal judgment.* There is no evading the issue.

Within certain limits of variation, almost any theory can be made to look plausible. Man tries desperately for some system by which variations can be

neatly catalogued so as to relieve him somewhat of the responsibility of making personal decisions. Nature, however, knows nothing but infinite variation, much of it extreme to a degree and in most unusual combinations.

Try as we will, infinite variation can be dealt with successfully only by the application of *principles* applicable to *all* cases and to *all* reactions and interactions concerned with them.

THE POSITION OF OPTIMUM OCCLUSAL RELATION

The essence of any problem consists in knowing what to do, when to do it, and how to do it.

As in orthodontics, we are dealing with living, functioning, human tissue which, when under treatment is in a constant state of flux, it is absolutely necessary to have instantly at one's command the means to glimpse, at least, an all-inclusive picture of a condition as it actually exists in its *entirety* and to be able to compare this with a more desirable arrangement which, in our imagination and judgment, is possible of attainment by means of orthodontic procedures. This is the crux of the matter, the pivotal point from which all constructive thinking should radiate.

This brings us face to face with probably the most important single problem in the entire field of orthodontics. As misery likes company, it is perhaps with an unworthy feeling of satisfaction to note that as orthodontists we are not alone in the field of dentistry in facing practically the same basic problem. The prosthodontists and the periodontists, in particular, are in the same boat with us.

This is the all-important matter of the position of the mandible in its relation to the cranium and face.

In this connection I would like to quote a few paragraphs from a recent paper on prosthodontics by Dr. Leof, of Philadelphia, with whom I also had a somewhat lengthy personal discussion of the matter:

"The concept of the physiologic rest position of the mandible and its definition are clear and well known. It is the position of the mandible at rest, with a small space of 2 to 3 mm. between the teeth in average cases. There is, however, a dictum connected with this rest position, that I do not accept. It is the dictum that "the physiologic rest position is constant throughout life.

"Let us start clarifying the situation by stating that the physiologic rest position is a physiologic manifestation and not an anatomic one.

"The physiologic rest position of the mandible is not controlled by muscle length. The physiologic rest position is controlled by muscle tone, or more precisely, by the balance of the muscle tone of two antagonistic groups of muscles. The masticatory muscles, the masseter, temporal and internal pterygoid have an upward pull on the mandible, while the suprahyoid and infrahyoid groups of muscles have a downward pull on the mandible."

MANDIBULAR SUSPENSION

"In our field of occlusal reconstruction we have no term for that composite of concepts which relate to mandibular position. Vertical dimension is just one small part of a larger group. I suggest the term *mandibular suspen-*

sion, which, when applied anatomically, would include the temporo-mandibular joints, the muscles, the tendons and all their attachments, from the bony muscle insertions in the skull to the muscle attachments of the infrahyoid group at the base of the neck. Used physiologically, the term mandibular suspension would include the physiologic rest position, centric relation, centric occlusion, and all mandibular movements. A discussion of mandibular suspension would then, obviously, involve a large group of concepts which have to do with the study of the mandibular position in all its phases."

In my own previous papers, I have stressed time and time again the importance of this vital problem, and have always given credit to the one man who coined a term to express somewhat the same basic idea as applied to orthodontics. I refer to Dr. Alfred Rogers.

As in orthodontics, we naturally never deal, as in prosthodontics, with edentulous cases; the terms expressing the same basic idea are not interchangeable.

In orthodontics we seem to be facing some confusion at present over the interpretation of the so-called "rest position." Some writers, both by their writings and their illustrations, seem to be using this term to indicate something which is quite different from what can be strictly defined as "the rest position." It would seem that this term is being used to indicate the position which Rogers called the position of "mechanical advantage" which, if I may use my own words for the interpretation of the term, is "that relation of the mandible to the maxilla which, visualizing the result at the end of treatment seems to be the most desirable from the standpoint of function and aesthetics, and which seems possible of attainment within the functional and structural limitations of the individual."

Without in any way detracting from Rogers' original and invaluable basic idea, it is possible that the time has come when we might consider a more comprehensive term for this all-important, yet highly speculative, position of the mandible. As our friends the prosthodontists are in search of a term suitable for their specialty, I would like to suggest *"optimum occlusal relation"* or *"optimum mandibular relation"* for consideration.

TREATMENT

Orthodontic treatment consists in making changes in the three dimensional relations of the teeth and their supporting tissues, changes in the temporomandibular joint including all its component elements, and changes in voluntary muscular functional activities, including personal idiosyncrasies and habits. To these should be added the matter of timing, both in regard to its chronological importance as to the best time at which treatment should be instituted, as well as the rate of procedure with which changes should be carried into effect.

If there is *one basic principle of universal application* more important than any other, it is hard to think of a more important one than that *form and function* go hand in hand, and are mutually interdependent on each other.

Placing the mandible in the position of *"optimum occlusal relation"* reveals the actual clinical problems concerned with each individual case so completely

and with such simple clarity that the best techniques for the treatment of the patient suggest themselves as natural, logical sequences.

Of all the forces placed at the disposal of orthodontists, there is none more immediately available, more natural, and more important than the volitional functional exercise of the patient's own muscular efforts. These efforts can be immeasurably helped by removing the immediate and plainly obvious *mechanical interferences* which the positions of optimum occlusal relation reveal to be present at each successive step of the treatment.

Not to take full advantage of the patient's own intelligent, cooperative, volitional muscular efforts in his own desires of self-improvement is as sensible as building a steam plant on the banks of Niagara and letting the natural water power, which is available for the taking, go to waste.

It has been said that "anyone who has grasped a 'principle' or 'method of approach' which is universal in character has in his hands the only weapon applicable to infinite variation. Techniques are mere servants to principle. When anyone takes over the technique of a predecessor without sharing the vision which animated it, he takes over a mental body but loses its immortal soul."

If there is any logic, reason, or common sense in the fact that the position of optimum occlusal relation reveals, more clearly than any other means available, the sum total of all the structural, functional, and esthetic problems of each individual case in *one single composite mental picture,* then it is equally important to realize that each individual picture is unique and calls for all the originality, mechanical ingenuity, and inventiveness of which orthodontists are capable in selecting the best mechanical means available as aids to nature. In this respect there is quite a selection available, and some of them are so infinitely better suited to meet individual clinical conditions than others that it is the height of stupidity not to be elective in this respect, rather than to hang doggedly to some mechanical gadgets which often interfere with the actual efforts of nature herself. It is about time that we should be getting rid of the "tyranny of specific appliances" and the narrow-minded arrogance which their exclusive use seems to generate.

At the present stage, no man can do more than present his own viewpoints and methods of procedure in the all-important questions of treatment so that they may be freely judged and criticized. There can be no progress without active, intelligent, constructive criticism to which no open-minded man should take offense.

In presenting this, therefore, the most important part of this paper, I would like to review a few principles which I think I have stumbled across more by accident and good luck than anything else, but which seem to have withstood the test of time. I tried to sum up these thoughts in a recent paper:

"The soundness of any philosophy depends on the degree with which its principles and techniques are in harmony with the immutable laws of nature, and should be accepted or rejected on that basis.

"There are several fundamental scientific principles to which any sound system of Orthodontics must of necessity conform.

"Practical results are obtained by effecting individual tooth movements, functional changes, and bodily readjustments of the mandible. These should be in harmony at all times, with our already well established knowledge of histology, anatomy and physiologic adaptability. In accordance with this knowledge, every tooth movement should be carried into effect by *no* means other than by gentle, continuous pressures on individual teeth, coordinating these movements in such a way that there may be but a minimum of traumatic occlusion while these movements are taking place between the teeth in the opposing jaws.

"Changes in position and growth of the mandible can only be produced where these changes are possible. These are mainly in the region of the temporomandibular articulation, including the neck of the condyles and the ascending sections of the rami. These can only be induced by appliances which permit of such freedom of movement that the functional efforts of the individual at all times may be utilized to the utmost advantage, and not hampered by artificial mechanical interferences.

"An Orthodontist need hardly go farther than to ask himself these fundamental questions in deciding on several of the most vital questions at issue and the methods and types of appliances he may reasonably employ in dealing with them. The ingenuity of free-thinking orthodontists has already provided the necessary implements with which to cope, adequately and safely, with all these basic biologic problems."

In a previous paper, "The Art of Orthodontic Practice," I stated as clearly as I could the principles of treatment which I had found most useful in my own practice, and also the appliances which I found most efficient. In order to make this paper as coherent as possible, I am going to repeat these briefly. I would like to say, however, that since my visit to New Orleans in November last, I have added to my repertoire the Crozat appliance. I have already started to use this very extensively, and my only regret is that I have not done so sooner. I feel that it is going to make a very marked change in the conduct of my practice from now on.

EXAMPLES OF TREATMENT

"The *first* and most important principle, or act of procedure, is to *study the position of 'occlusal advantage'* in its most comprehensive aspect and allow full rein to one's creative imagination, tempered, of course, by logic and common sense. This is the nearest approach to reducing to a *'single mental picture'* the entire panorama of any case with its individual problems and the means of treatment best suited to them.

"The *second principle* consists in devising *for each successive step* in treatment the appliances best suited to the *problems of the moment,* coordinating the actions of the appliances used in the opposing jaws in order to avoid all possible trauma and allow the utmost freedom of movement of both the jaws and teeth while changes are taking place.

"The *third principle* of treatment is that as action is followed by reaction, which is never quite predictable, a complete *re-evaluation of the entire case*

should be made at *each visit* of the patient. The position of *occlusal advantage* should be constantly studied in minute detail. Depending entirely on the changes which have taken place between visits, should the decision be made whether to continue with the means which are being employed, or to discard them for something entirely different, either because the effect has not been what was expected or the desirable changes which have been obtained suggest something entirely different for the next move.

"Treatment is based on strategy from start to finish. Not the strategy of this or that appliance, but an all-inclusive strategy which may include the use of all types of appliances as long as they are used at the time best suited to the problem of the moment.

"The *fourth principle* is that as orthodontic treatment is performed on living functioning human tissue, subject at all times to the voluntary muscular efforts and intelligent mental cooperation of the individual for whom the work is being done, no work should be undertaken without having first prepared carefully the groundwork to insure these efforts to the utmost during the entire time that the case is under treatment. . . .

"If these *principles* of procedure have any merit, it is just as important that the means employed in carrying the desired changes into effect should be in complete harmony with them. This involves the selection of appliances as well as the control of the muscular and mental efforts which must be exercised. It is entirely logical and practical to coordinate all of them. In my own practice, I employ four types of appliances which I also place, in accordance with my own methods of procedure, in their respective order of importance.

"*First,* the plain labial arch with the infinite variety of labial auxiliary springs adaptable to its use. This appliance makes possible every conceivable individual tooth movement without disturbing basic anchorage, and also permits the simultaneous movement of anchor teeth with other individual tooth movements, without the movements of the one interfering with the other.

"*Second,* bite planes in every form and description for the reason that through their use we make available the *natural force of occlusion* not only to produce tooth movements, but, what is still more important, to produce bodily movements of the mandible in its cranial relations and changes in the temporomandibular articulation. In the light of practical results and the rapidity with which some of these mandibular changes take place, it is my opinion, corroborated with that of a well-known radiologist, that some of the most important anatomical changes which occur as a result of treatment are mainly in the necks of the condyles. In some of these spectacular mandibular changes, the entire functional pull of the muscles is altered with untold benefits, not only to the function of mastication, but to facial contour as well.

"*Third,* lingual arches with the infinite variety of auxiliary springs which may be used with them. They are the only logical types of appliances to be used for some tooth movements. In the forms of cribs or 'guide' planes . . . they have their very definite place. There is a very subtle line of demarcation between the choice of guide planes and removable plastic bite planes in treatment.

"*Fourth,* the Joseph Johnson twin wire labial appliance, which is par excellence the best suited for cases where the compensatory effect of its gentle pressure can be exerted simultaneously on a number of teeth, particularly multiple incisors. In skillful hands, and in accordance with Dr. Johnson's methods of procedure, it has a very great latitude of usefulness."

In estimating the value of appliances it is often interesting to pick out some unique situation and consider which type of appliance is the best suited for that particular problem. I still feel that the plain labial arch with the infinite variety of auxiliary springs which can be used in connection with it has a greater range of adaptability than any other appliance which I can think of. It permits of gentle, continuous pressure on individual teeth while at the same time not disturbing basal anchorage, and allows for a wonderful method of coordinating the movements of the teeth of the opposing jaws.

A. *B.*

Fig. 4.—*A* and *B*, Comparisons in the proportion of the teeth to the sizes of the head and facial features of two perfectly healthy, normal individuals.

Judgment is based on observation and comparison. Some comparisons are exceedingly helpful in establishing concepts of our objectives together with their limitations.

Fig. 4, *A* and *B* are photographs which have been carefully blown up to the same size in order to show, as clearly as possible, the vast difference there is between the proportionate sizes of the teeth, their supporting tissues, and the face. In the case of the young lady shown in *B*, the only solution which was found feasible in this case in order to produce the nearest approach to the three objectives of orthodontic treatment, structural balance, functional efficiency, and esthetic harmony, was the removal of the six maxillary incisors, together with a large amount of alveolar process. The unfortunate conditions which this case represented were evidently an inherited characteristic, an aunt of this young lady having had the same problem which was solved in the same manner.

Fig. 5, *A* and *B* present other problems to make the life of an orthodontist interesting. It is naturally possible to place teeth only where there is sufficient bone to support them. The lack of alveolar process in the region of the upper left lateral incisor and canine in the case of *A*, together with their occlusal relation with the mandibular teeth, presented an exceedingly difficult problem. The

A. *B.*

Fig. 5.—*A* and *B*, Variations in the facial features and bony distribution for the accommodation of teeth between two widely diverse types.

A. *B.*

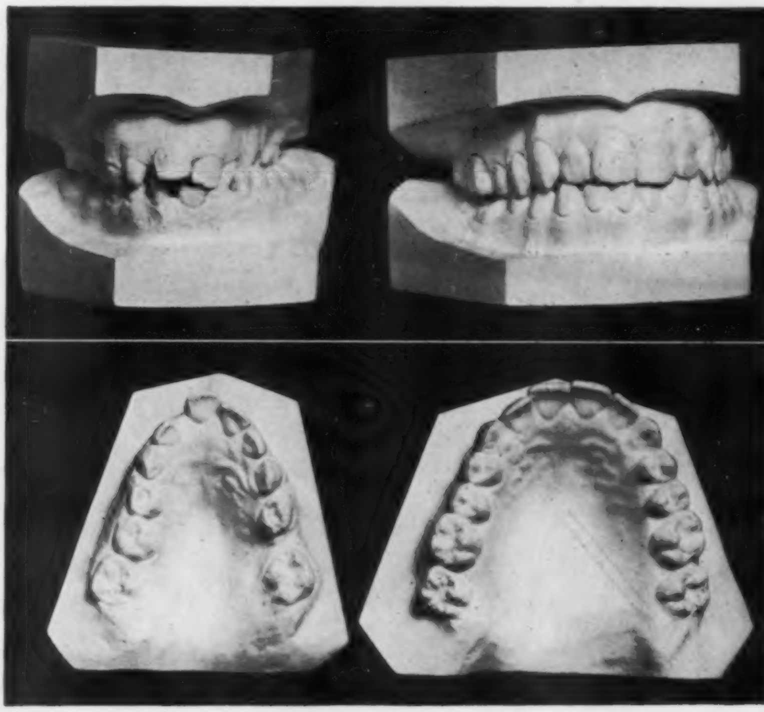
Fig. 6.—*A*, Exceedingly "satisfactory" dental occlusion; *B*, An "unsatisfactory" dental occlusion with the patient biting in the position of "optimum occlusal relation."

flabby muscular tone, together with the small mandible in *B*, presented factors which made a combination of all the desirable objectives of treatment quite impossible. As long as an orthodontist has done the utmost within the biologic limits of a case, he has done all that is humanly within his power to accomplish.

Fig. 6, *A* represents an exceedingly "satisfactory" dental occlusion combining all the desirable qualities which that term implies.

Fig. 6, *B* is a very "unsatisfactory" occlusion with the patient biting in the position of "optimum occlusal relation." It is exceedingly helpful to make

A.



B.

C.

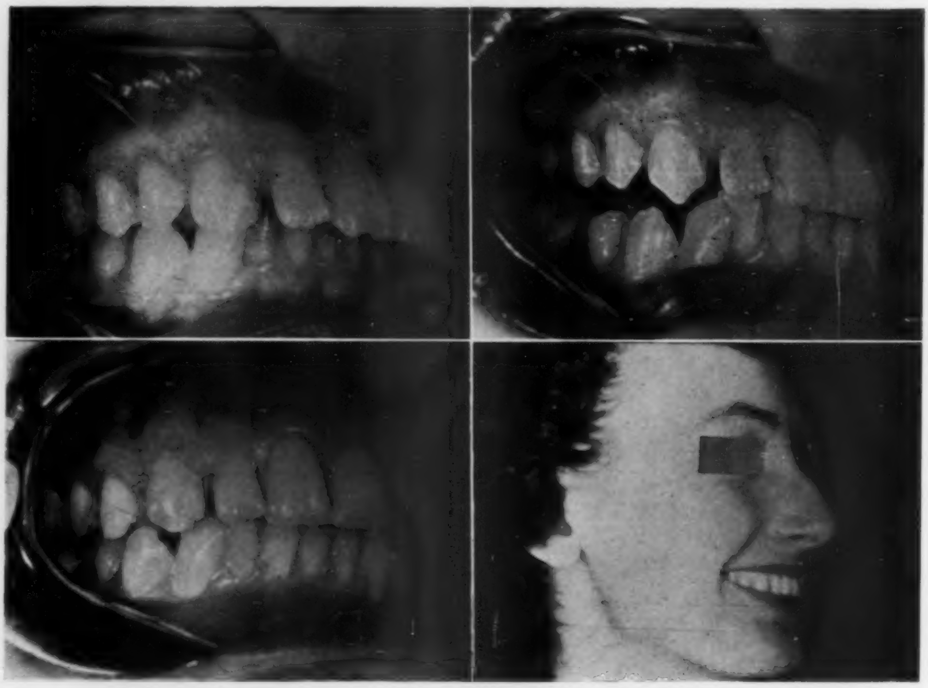
Fig. 7.—*A*, *B*, and *C*, Extreme constriction of a maxilla due to improper function (cross-bite) showing results of treatment. Has the amount of expansion in this case been justifiable?

comparisons of this kind so as to get a true picture of the factors we are dealing with in their most comprehensive manner. It is very dangerous to think about teeth too individually. It is obvious by a comparison of these pictures that the

main things we should be thinking about are bony masses and changes in the temporomandibular articulation. Just exactly what a composite of all these changes actually are in a completed case is undoubtedly exceedingly complex.

Fig. 7 presents a typical example of the axion that form and function go hand in hand and are interdependent on each other. Due to the mutilation which this case also presented, a considerable amount of mechanical strategy had to be employed to obtain the result which is shown. No appliances were used on the mandibular teeth. This case also presents an interesting problem in the question of molar and premolar expansion. How much of the original constriction was due to function and how much to natural genetic pattern? Did I do wisely in expanding this case as much as I did?

A. *B.*

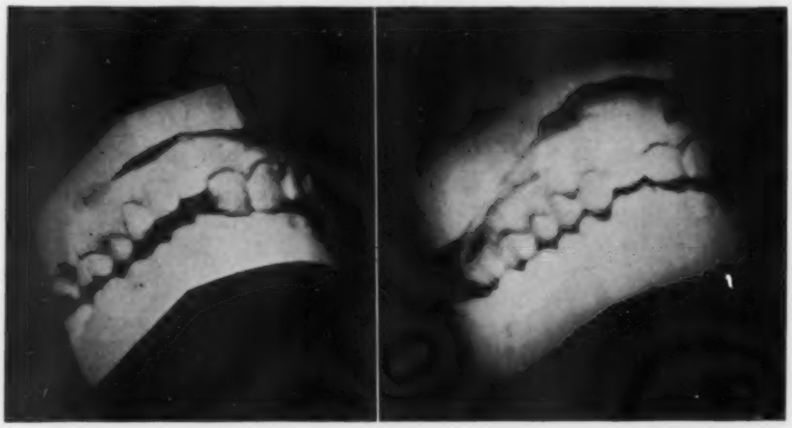


C. *D.*

Fig. 8.—*A*, An unsatisfactory natural occlusion; *B*, biting in the position of "optium occlusal relation;" *C*, after treatment; *D*, facial appearance of patient after treatment. This case was treated mainly with bite planes and a great deal of myofunctional exercises on the part of the patient.

Fig. 8, *A* shows a patient biting in natural occlusion, *B*, biting in the position of optimum occlusal relation, *C*, in the occlusal relation after treatment. This case was mainly treated with working retainers and a great deal of interest and personal effort on the part of the patient.

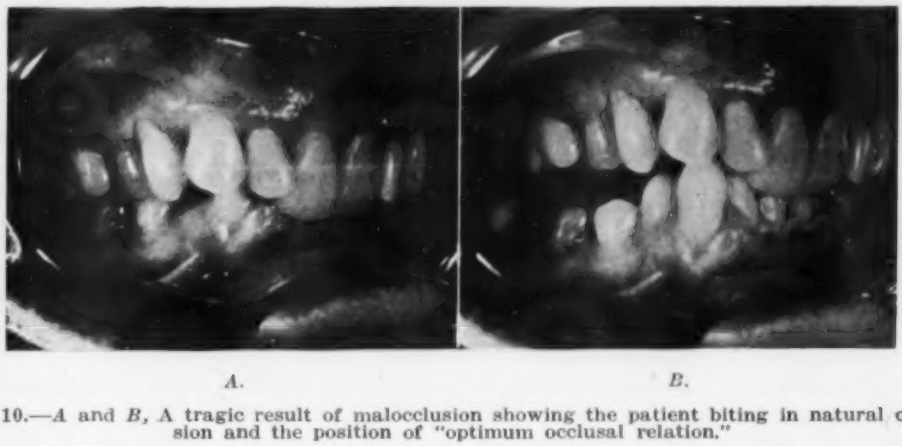
Fig. 9 represents a case treated many years ago which I think impressed on my mind something which I have always considered of prime importance. If we compare the original condition of this case with those in Fig. 10, it is obvious that a totally different arrangement in the vertical relations has been produced.



A.

B.

Fig. 9.—*A* and *B*, Treatment of a case of deep overbite in unilateral distoclusion. The vertical readjustment which was obtained is usually a strong guarantee of permanence of result. This result was obtained to a great extent by a long, continuous use of an acrylic retainer.



A. *B.*

Fig. 10.—*A* and *B*, A tragic result of malocclusion showing the patient biting in natural occlusion and the position of "optimum occlusal relation."

In cases of this kind the molars and premolars should be elongated and the incisors should be depressed in order to produce an arrangement which comes under that elusive concept known as the "curve of Spee." It was with this in mind that I played around with labial auxiliary springs for many years until

A. *B.*

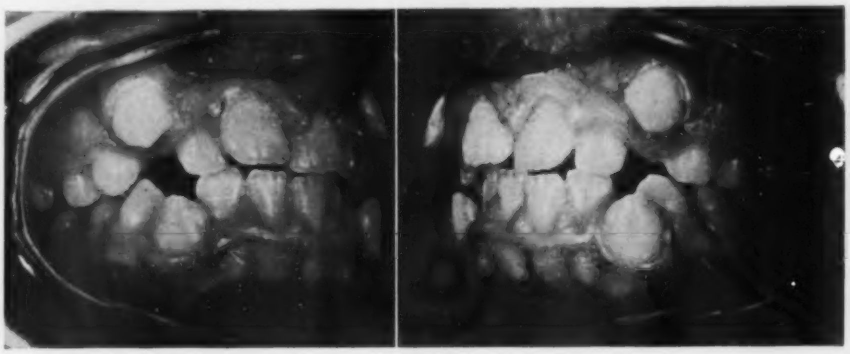
C. *D.*

E.

Fig. 11.—*A* and *B*, Models of a young girl with a very deep overbite somewhat similar to Fig. 10; *C* and *D*, Result of treatment showing improvement in mandibular relation and vertical development; *E*, facial balance of case.

my associates and I finally devised that appliance which I have described in full detail in previous articles and dubbed the "double boiler." This, together with cribs and bite planes, is the most efficient method I know of for producing this

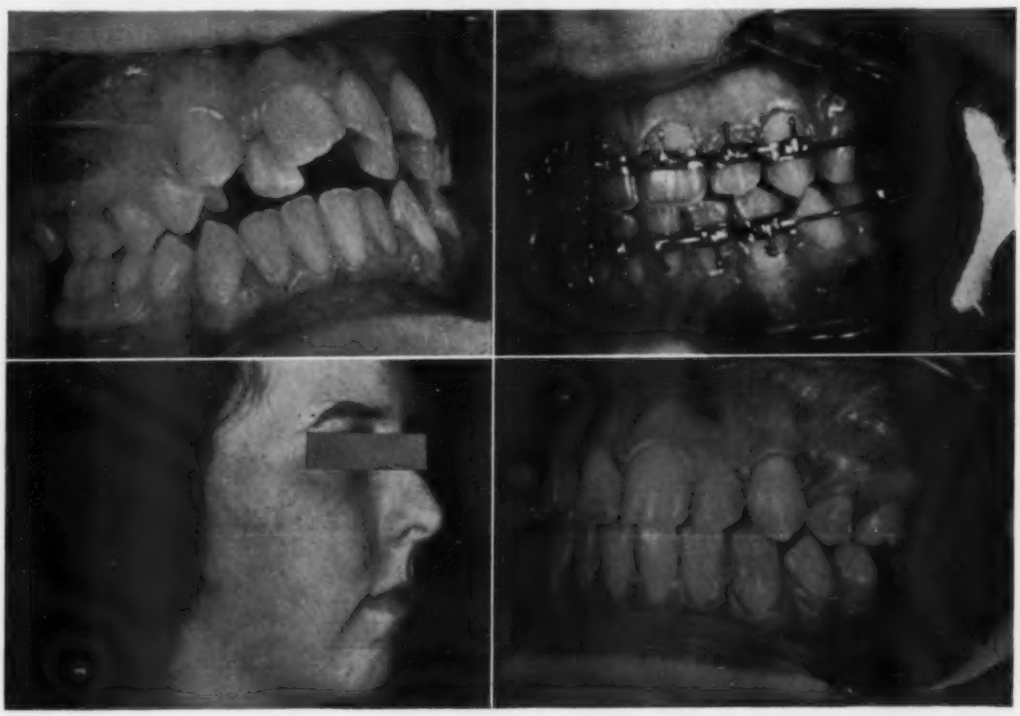
vertical rearrangement. When the occlusion of the teeth is finally established as a *unit* in this manner, the results are usually exceedingly satisfactory and permanent, and the changes are often accomplished within surprisingly short spaces of time.



A. *B.*

Fig. 12.—*A* and *B*, Gross disproportion between the sizes of the teeth and development of the jaws. Four premolars were removed and it is likely that a very satisfactory result will be obtained without any mechanical therapy.

A. *B.*



C. *D.*

Fig. 13.—*A*, *B*, *C*, and *D*, Gross disproportion between the sizes of the teeth and the maxillary development. The condition of open-bite combined with the exceedingly unfavorable mandibular angle made this an exceedingly dangerous case to treat conservatively. Two maxillary premolars were removed and the case was treated with the Johnson twin wire appliance, with the result as shown.

The case represented in Fig. 10 is naturally a complete wreck, and at the age of this patient, quite beyond the range of orthodontic help. One of the main objectives of orthodontic treatment is naturally to prevent these things from developing.

Fig. 11 shows a case of a very young girl who has been considerably improved by orthodontic help. This young lady is now wearing a bite plane retainer which it is essential to wear for a long period of time. The enormous amount of bony development in proportion to the tooth substance and the axial inclination of these teeth is unsatisfactory, but there are many things about nature which we can only accept as they are.

Fig. 12 represents a condition which is exactly the opposite of that in Fig. 11. The lack of bony support, the open-bite condition of the teeth, together with an exceedingly bad facial balance, dictated the advisability of the removal of four premolars and letting the case ride without any mechanical interference over a long period of time. The improvement which has taken place in this case has already been remarkable. Orthodontic treatment in every case is either an aid or a compromise with nature.

Fig. 14.

Figs. 14, 15, *A* and *B*, and 16, *A* and *B*.—A case of extreme overjet with lack of vertical development in the molar and premolar region. Treated with a combination of bite planes and the "double boiler" labial appliance with the facial improvement shown in Figs. 15 and 16.

The problem of extraction naturally is always with us, and we still seem to be considerably divided in our opinions. The patient in Fig. 13 had had several years of orthodontic treatment of a "conservative" nature before coming to me. If there is one dictum in the question of extractions which I feel safe to make at this time it is that in all those cases in which open-bite exists, or there is the slightest tendency to produce one, it is an exceedingly safe thing seriously to consider extraction. This was done in this case, using the Johnson twin wire appliance in treatment, with the result which is shown. A mere cursory glance at the patient's facial balance and mandibular angle, I think, is sufficient to indicate to anyone who has had some clinical experience that this would be an exceedingly dangerous case in which to attempt to make changes in the mandibular relation. The result in this case can never be entirely satisfactory. The parents of the child, however, were exceedingly pleased with what was accomplished.

Figs. 14 to 16 involve another case of that ever-present problem of vertical relations. It will be noted in the original models that the first molar relations are satisfactory but the case clinically had all the appearance of a case

A. *B.*

Fig. 15.

A. *B.*

Fig. 16.

Figs. 15, *A* and *B*, and 16, *A* and *B* (*For legend, see opposite page*).

of distoclusion with protruding incisors. This case was treated by combinations of bite planes and the "double boiler" with the results which are shown in the facial photographs.

I happen to have a cephalometer which I have been using, so far, in a rather desultory fashion. Even without its use, however, a comparison of the facial photographs indicates quite clearly the changes which have actually taken place. James D. McCoy has shown what these changes are very clearly in his beautifully recorded case reports over the years.

Fig. 17 is just a photograph of an appliance which is a combination of the plain labial arch with a few variations of the auxiliary springs which can be used with it. In this connection I would like to show a case which was treated twenty-five years ago by means of a plain labial arch with auxiliary springs. This was a case in which I moved a maxillary canine, which is shown in Fig. 18, which lay originally between the molar and the second premolar. This was moved by a spring, which is sketched roughly in the illustration, to the place which it was intended by nature to occupy. I sincerely hope that I have developed sufficient common sense over the years not to attempt a tooth movement of this kind at the present time. However, the point I wish to bring out is that the *method* of accomplishing this movement by gentle, continuous pressure is sound and makes possible some very extensive movements quite safely. This patient dropped into the office recently, at which time I took a photograph of her. She is now a married woman with children and, notwithstanding the wear and tear of life and the fact that she is in her forties, that tooth, like "The Star-Spangled Banner," "is still there" and doing good service.

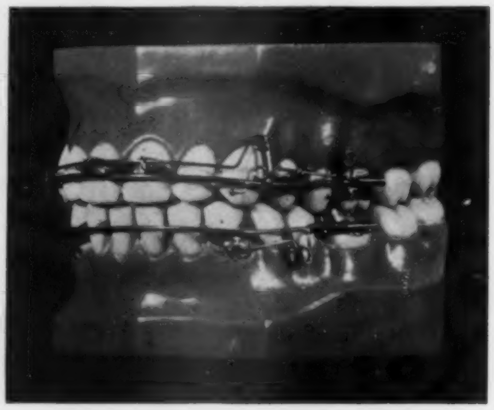
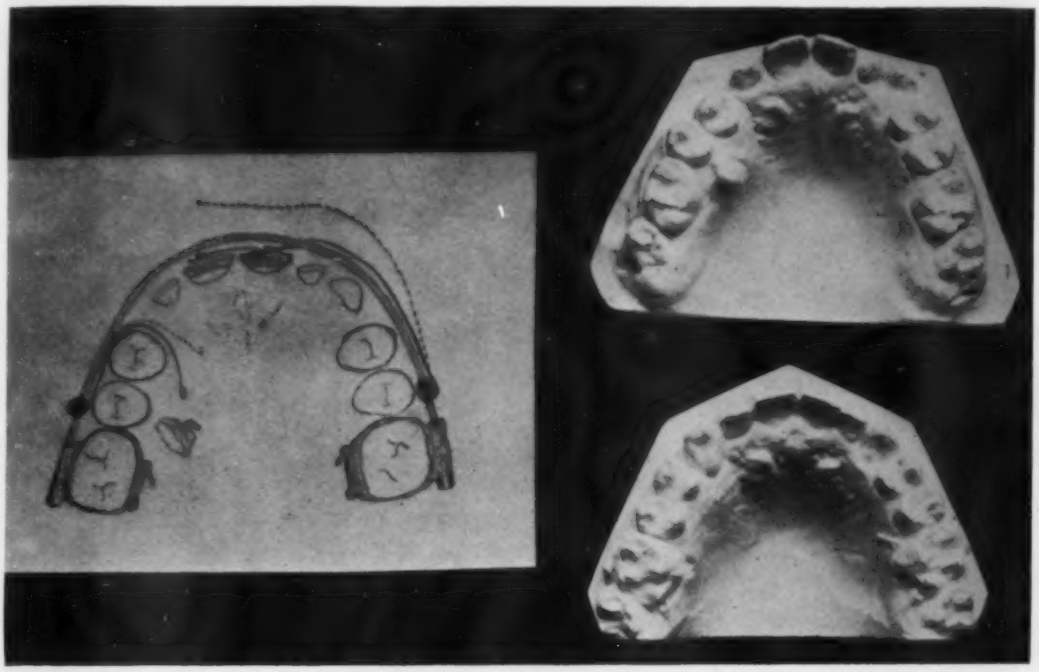


Fig. 17.—Plain labial arches with auxiliary springs. This type of appliance permits of downward and backward movement of the molars and premolars while the labial auxiliary springs are exerting a gentle, continuous pressure on the upper incisors in any direction which is desired.

Naturally we come across a great many cases in which canines erupt in the palate and have to be moved into position. A case of this kind is shown in Fig 19. At the present time I try to use onlays over the cusps of the teeth on which to solder attachments in order to get the gentle, continuous pressure from labial auxiliary springs. These are shown also in Fig. 19 with the result which was obtained in the case which is illustrated. I know of nothing which is more efficient for the movement of these teeth than this method of procedure.



A.

B.

Fig. 18.—*A*, Extreme movement of a single tooth by means of a labial auxiliary spring; *B*, Photograph of the patient fifteen years later.

A. B.
C. D.
E. F.

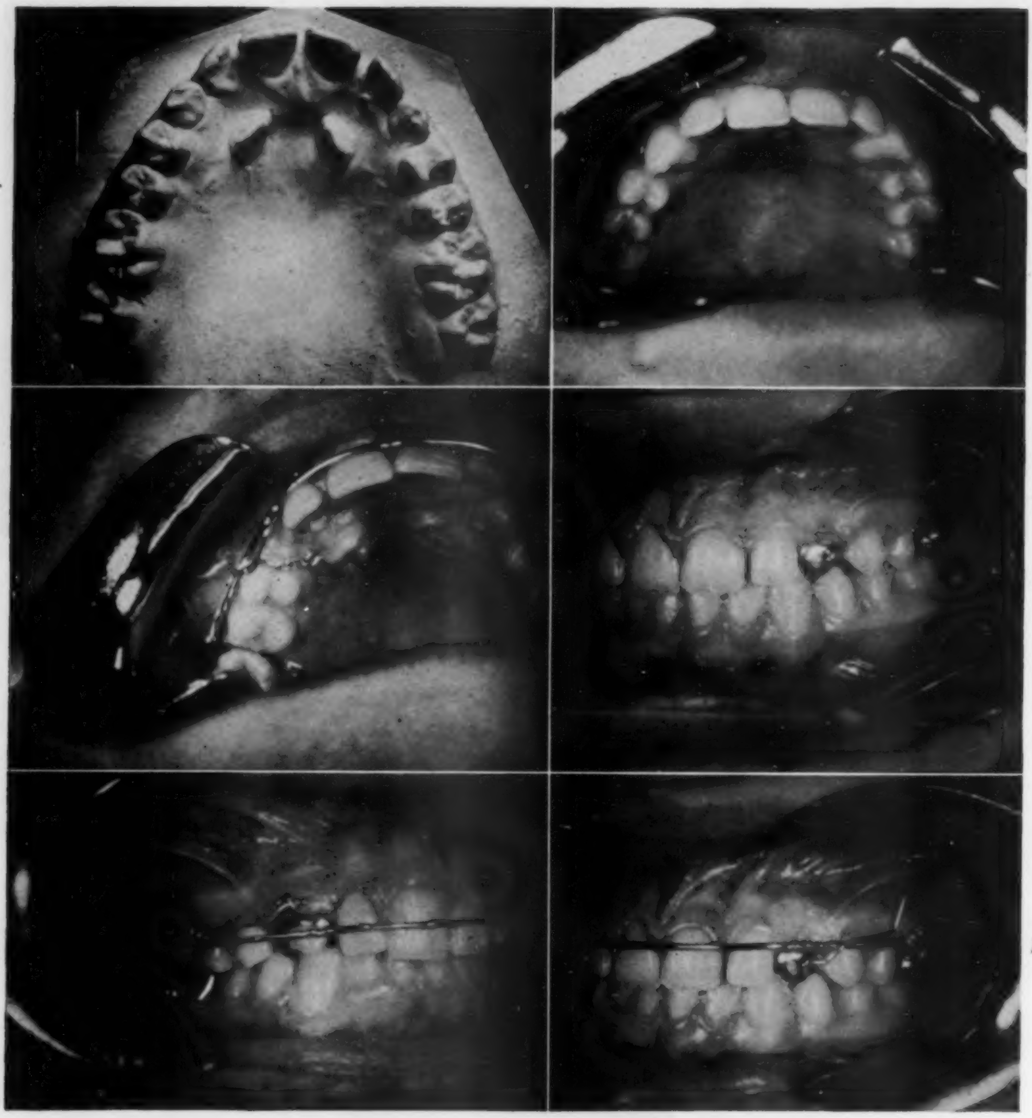


Fig. 19.—*A*, *B*, *C*, *D*, *E*, and *F*, Technique of moving canines in linguoversion by means of individual auxiliary labial springs.

A. B. C. D. E. F.

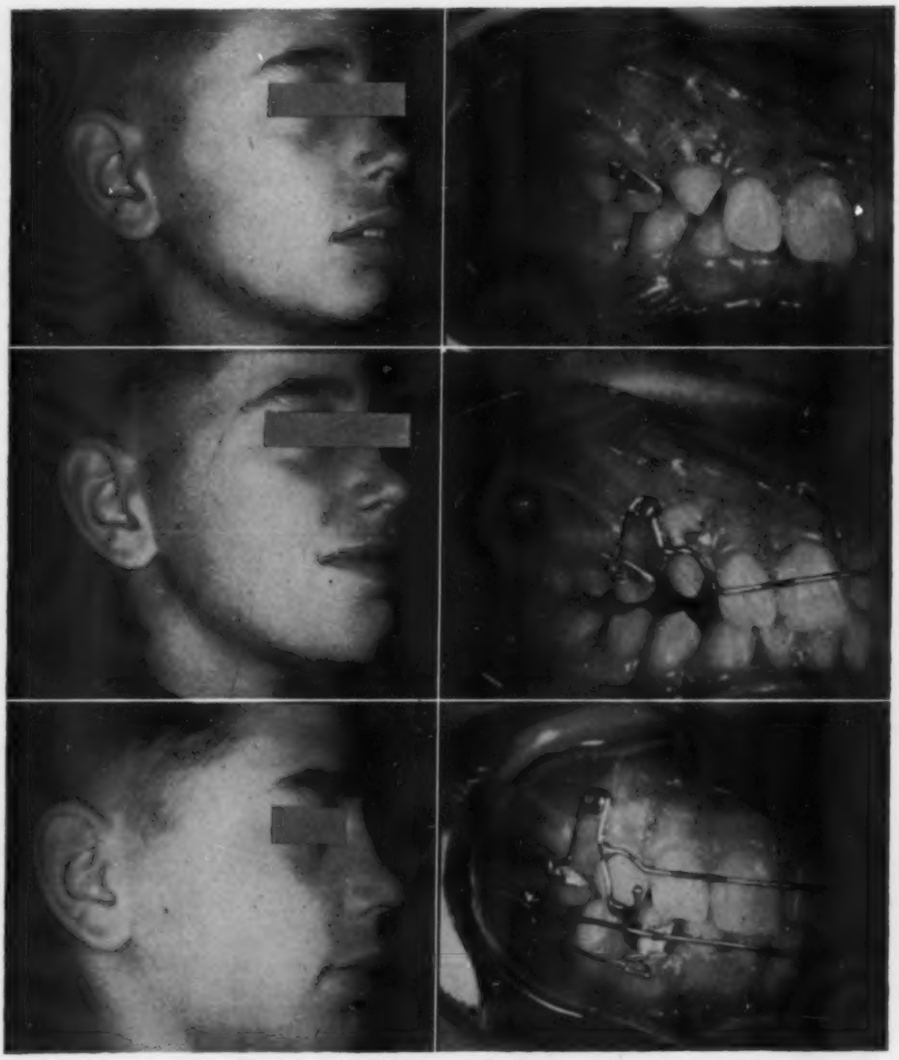
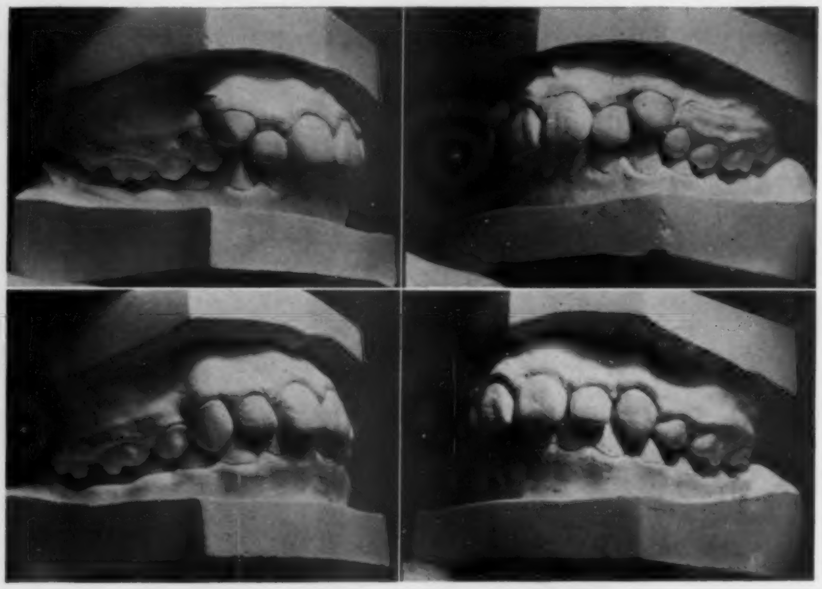


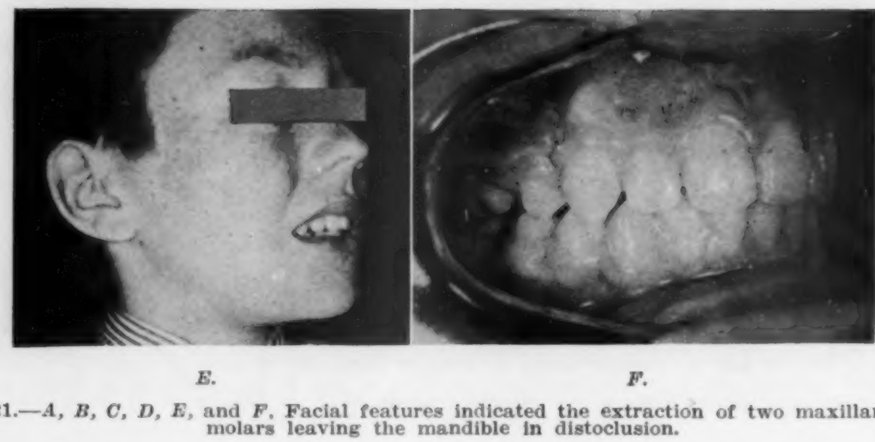
Fig. 20.—*A* and *B*, Patient biting in natural occlusion; *C* and *D*, biting in position of "optimum occlusal relation" with working retainer; *E* and *F*, improvement in facial balance and vertical development after a few months of treatment.

Fig. 20 is one of the usual cases of distoclusion with deep overbite which are so common. I like to treat these cases fairly early in order to keep the condition from getting worse, and when it is possible to get good cooperation from the patient, it is amazing how much can be accomplished with the use of simple working retainers. In *B* we see the original condition of the bite; in *D*, the vertical condition which the case presented when the working retainer was

A. *B.*



C. *D.*



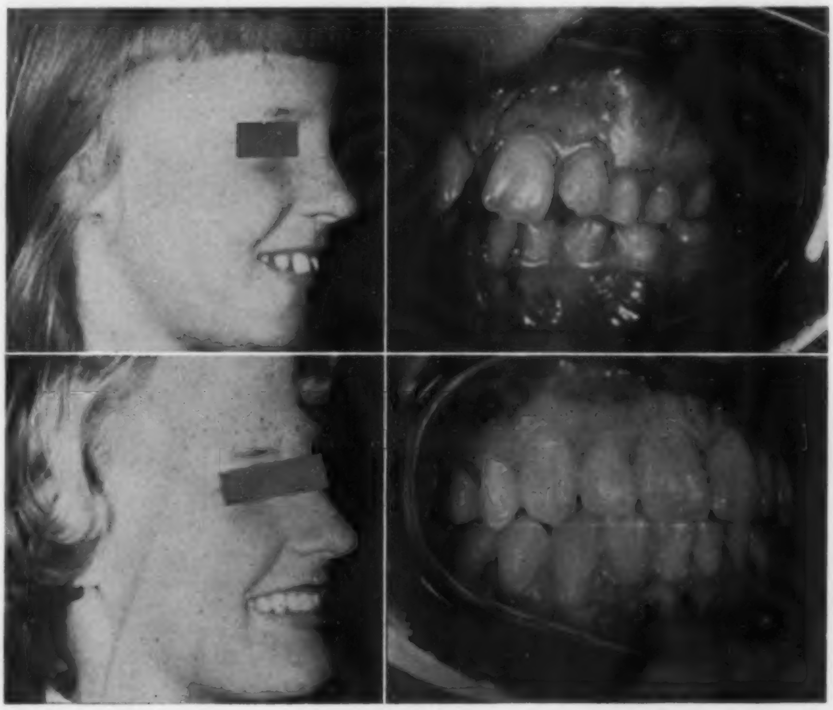
E. *F.*

Fig. 21.—*A, B, C, D, E,* and *F*. Facial features indicated the extraction of two maxillary premolars leaving the mandible in distoclusion.

first inserted, and in *F*, the changes which have taken place over the course of a few months. With the auxiliary springs which are placed on the premolars these working retainers have great stability so that intermaxillary elastics can be used with them in combination with fixed mandibular appliances. The changes in the facial balance can be noted from a comparison of the facial photographs.

Fig. 21 is another case of distoclusion with crowded incisors. A very superficial study, however, of the facial features makes all the difference in the world between the way this case is treated as compared with the one just described. This patient had a well-developed chin, a very small nose, and a very short upper lip. The only logical thing to do in order to attain the three objectives is, therefore, to remove two maxillary premolars and leave the mandibular relation in distoclusion. It does not take the reasoning powers of a genius to make decisions of that kind in cases like this.

A. *B.*



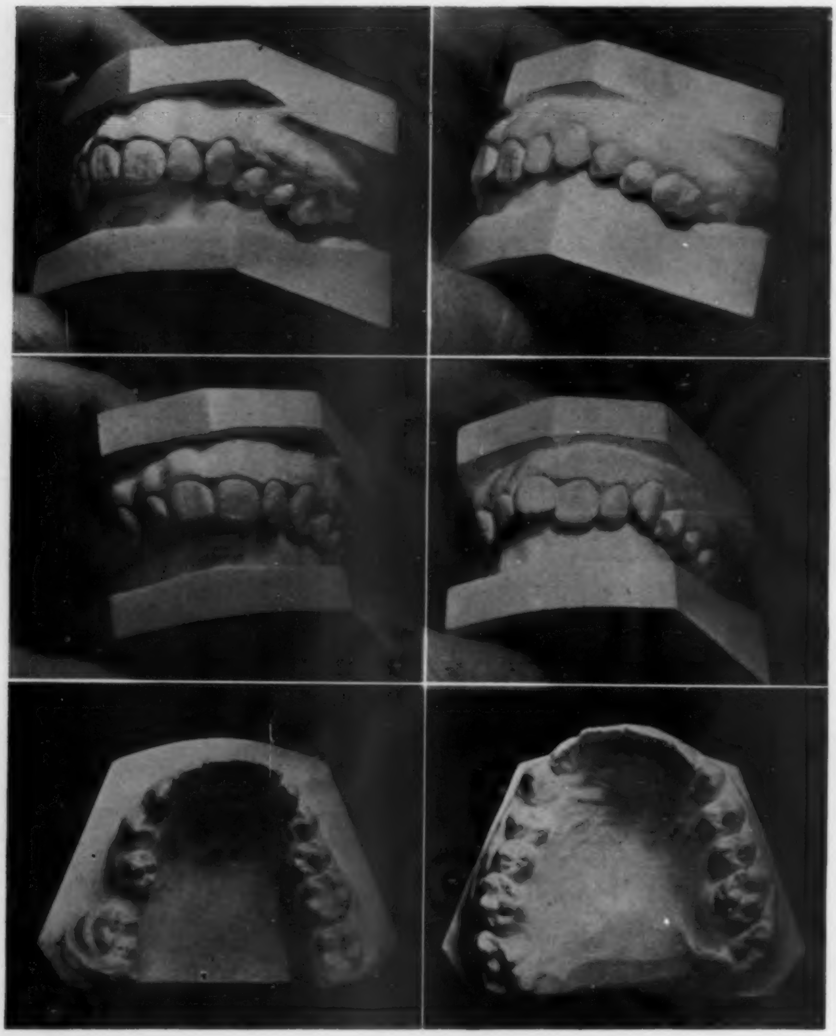
C. *D.*

Fig. 22.—*A*, *B*, *C*, and *D*, Treatment over a long period showing facial development producing a very pleasing appearance.

Fig. 22 is another case of distoclusion with mutilations and cross-bite. The treatment of this case was started quite early and extended over a considerable length of time because, among other things, the maxillary right canine erupted practically above the right lateral incisor. The question which arises, from a study of the final result, is "Might it have been wiser to have extracted four premolars in this case?" There is a slight amount of structural unbalance, but the resulting facial balance is so thoroughly satisfactory that it presents a very delicate clinical problem.

The case shown in Figs. 23 to 25 is included in this list of cases because it is a fairly complicated one to treat, and whether the methods I have used are right or wrong, it at least gives an opportunity of explaining how the principles which I have found useful are put to work. It will be noted that the

A. B.



C. D.

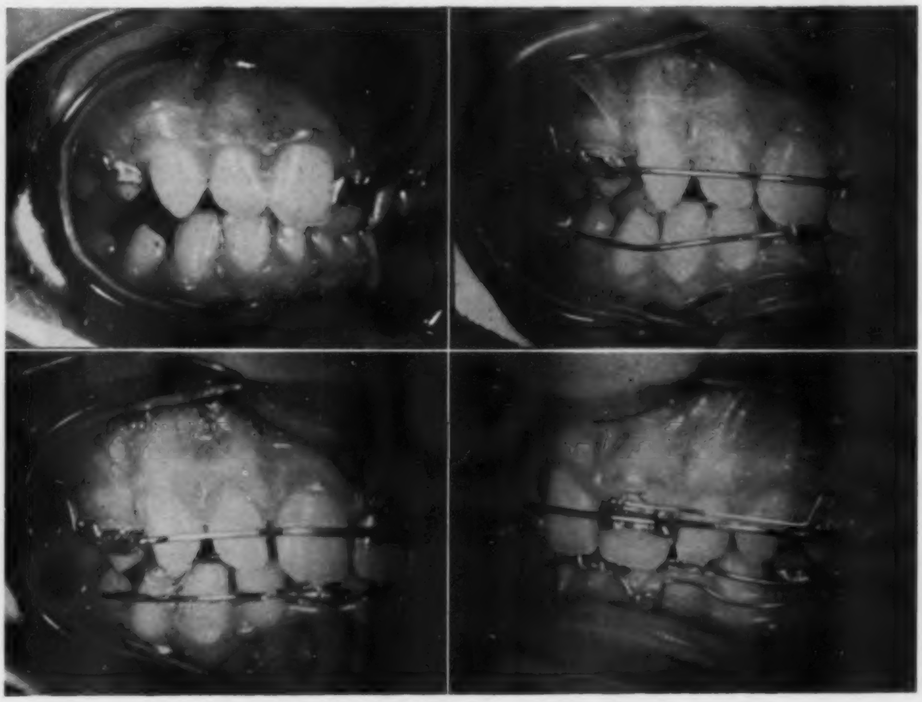
E. F.

Fig. 23.

Figs. 23, *A*, *B*, *C*, *D*, *E*, and *F*, 24, *A*, *B*, *C*, and *D*, and 25, *A*, *B*, *C*, *D*, and *E*.—Treatment of case employing basic principles which have been fully described.

maxillary molars and premolars on the left side are in complete buccal relation to the mandibular molars. The mandibular teeth on that side have been complicated by the premature extraction of the six-year molar. This condition having continued for some time, the maxillary and mandibular molars and premolars on the left side are in supraclusion as compared to the corresponding teeth on the right side. The very unsatisfactory vertical relation of the teeth is seen by placing the jaws in the position of "optimum occlusal relation" as shown in Fig. 24, *A*. This case was treated by inserting a bite plane and at the same time moving with labial arches and auxiliary springs the teeth which were causing the immediate obvious occlusal interferences. A certain amount of strategy was used in moving the mandibular premolars, which were in lingual occlusion on the left side, over to their correct buccolingual relations.

A. *B.*

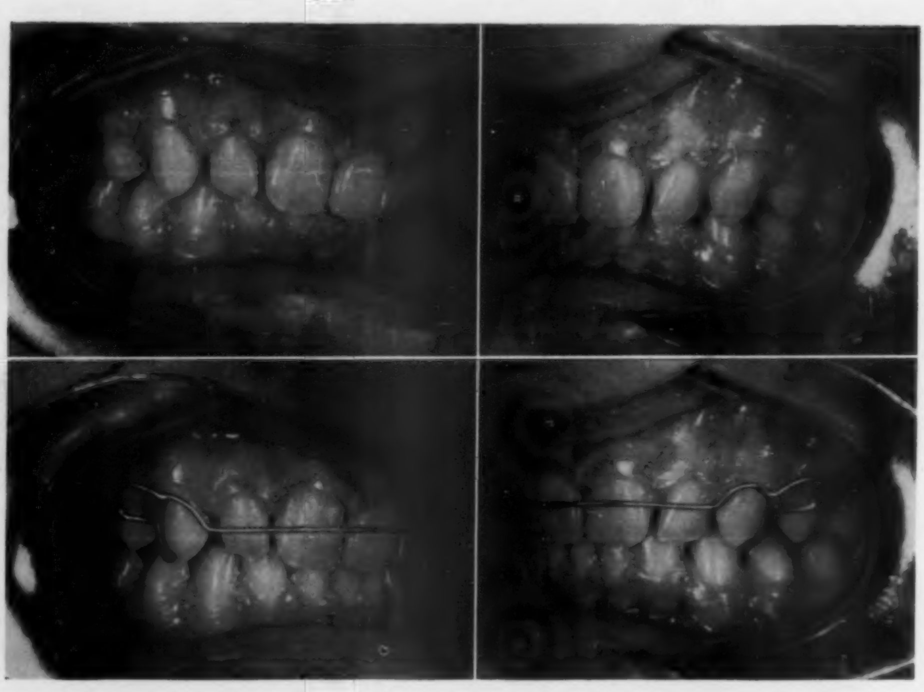


C. *D.*

Fig. 24.—*A*, *B*, *C*, and *D* (*For legend, see opposite page*).

This was accomplished, however, with the results shown in Fig. 25, *A* and *B*, at which time a new working retainer was inserted to allow for further vertical development and readjustment in the region of the molars and premolars. This case is at present still under treatment, the result so far having been enormously aided by a very cooperative patient. A comparison of the overbite as shown in Fig. 24, *A* and Fig. 25, *A* shows the great amount of vertical change which has taken place. This is one of those complicated types of cases where the more the patient's functional activity can be utilized in effecting these complex changes, the simpler and more natural is the treatment.

A. B.



C. D.

E.

Fig. 25.—*A, B, C, D,* and *E* (*For legend, see page 668*).

A. B.

C. D.

E. F.

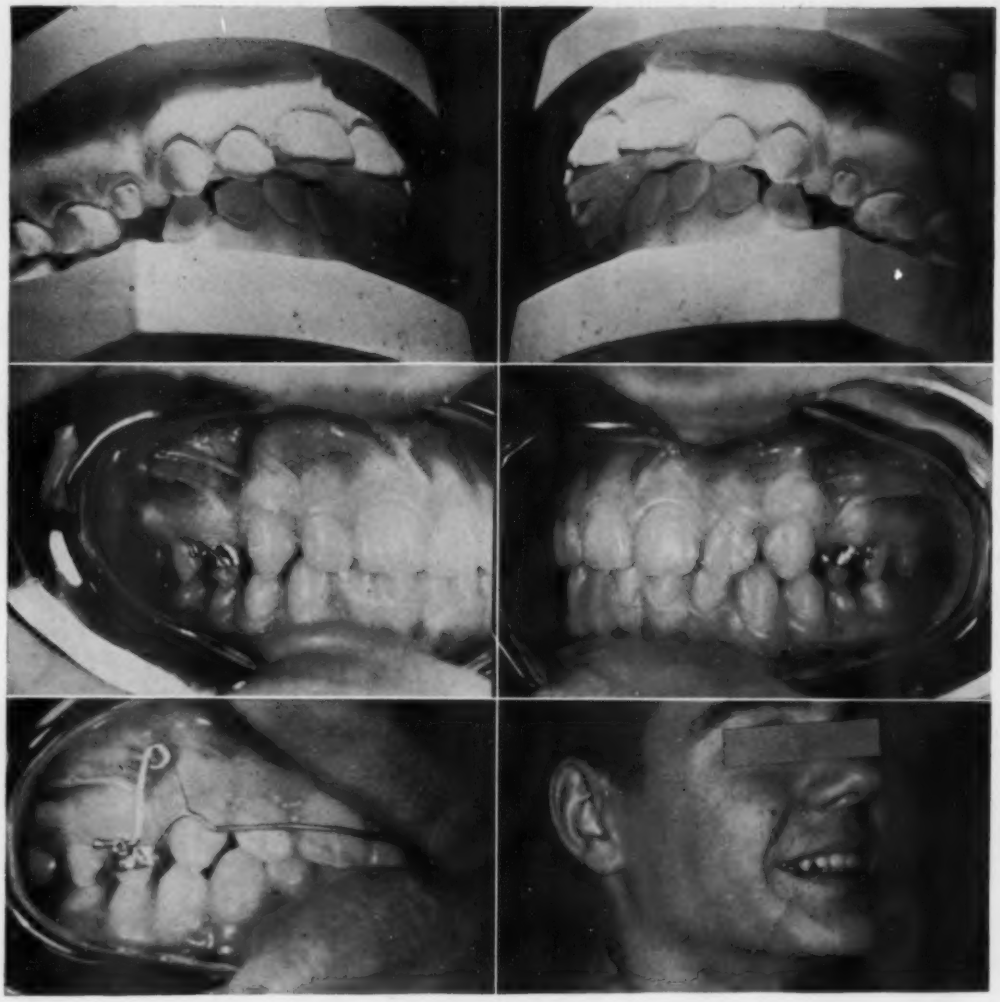


Fig. 26.—*A*, *B*, *C*, *D*, *E*, and *F*, Typical distoclusion case treated with minimum of mechanical appliances.

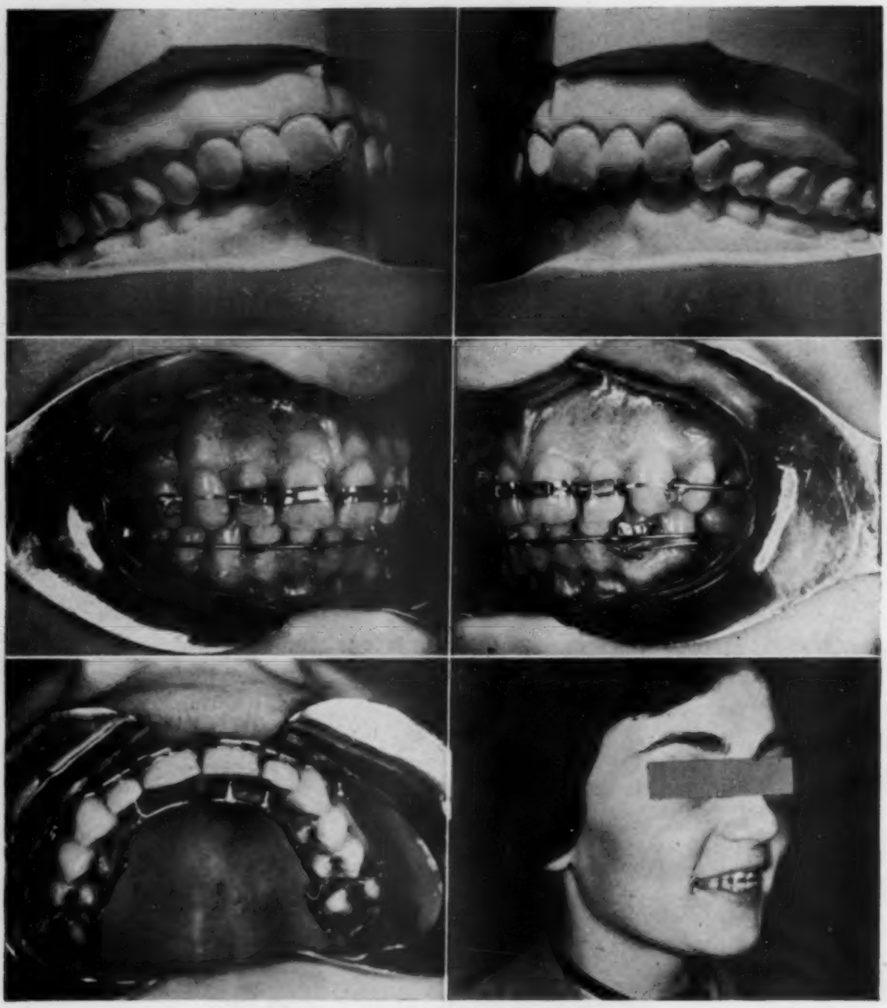


Fig. 27.—*A, B, C, D, E,* and *F,* Treatment combining Johnson twin wire appliance and lingual crib.

A. B. C. D.

Fig. 28.—*A*, *B*, *C*, and *D*, Osteotomy of mandible.

A. B. C. D.

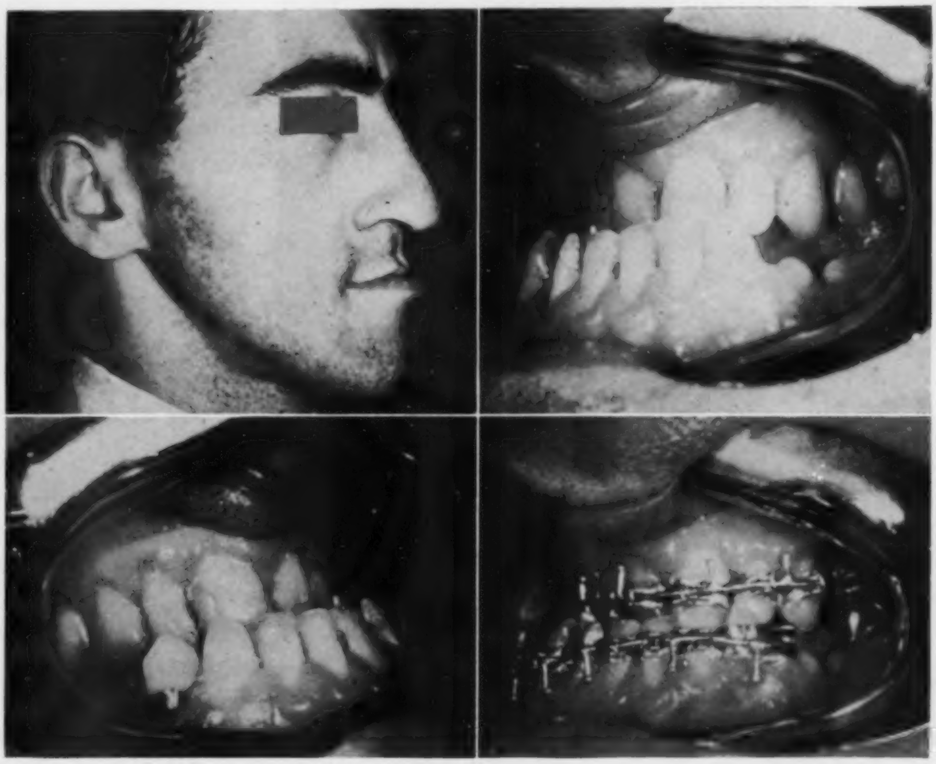
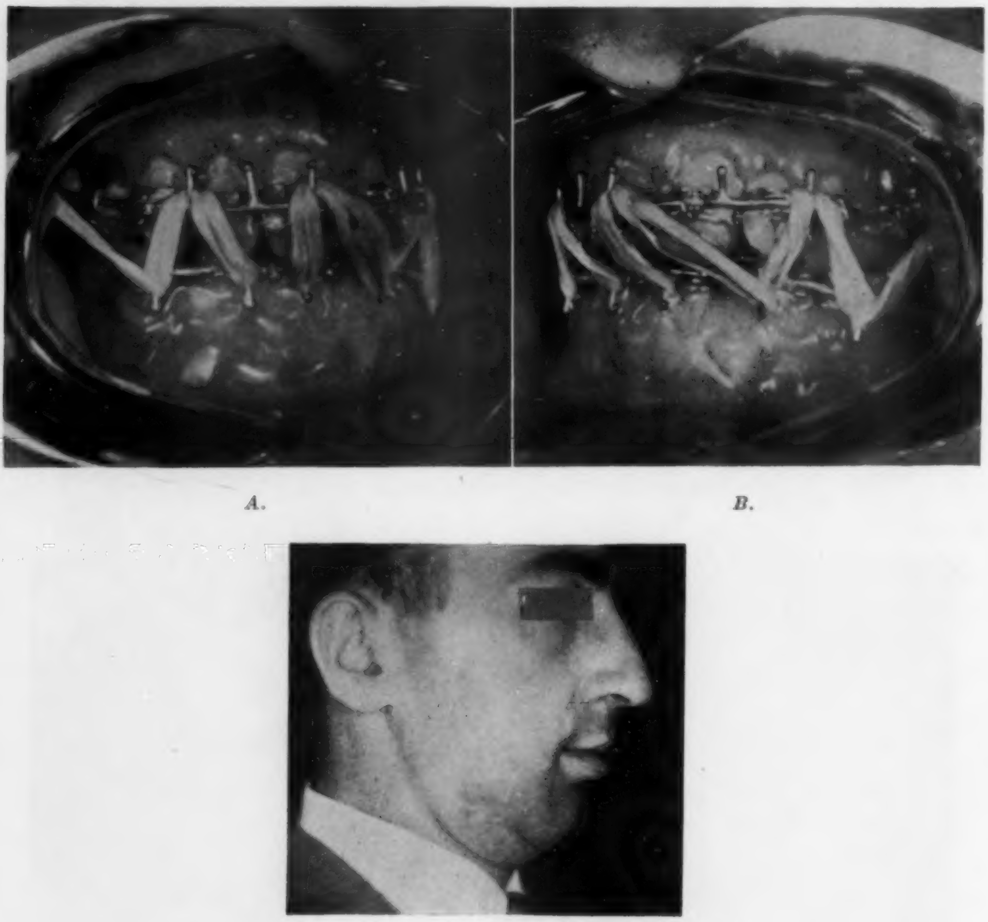


Fig. 29.—*A*, *B*, *C*, and *D*, Ostectomy of mandible.

Fig. 26 is another case of distoclusion with protruding incisors. This case was also treated in the manner described without the use of headcaps, and with as few bands as possible. We still have a lot to learn about these cases because there is such an enormous difference in the way they react to treatment. It looks as though we ought to study much more closely the changes which take place in the temporomandibular articulation and its associated parts.



A. B.

C.

Fig. 30.—*A*, *B*, and *C*, Ostectomy of mandible.

Fig. 27 is a case which was treated by a combination of the Johnson twin wire appliance on the maxillary teeth, a lingual crib, and a lower labial arch. Here again the use of the lingual crib is of enormous value in repositioning the mandible and allowing for vertical development in the molar and premolar region. The treatment of this case was started only on Dec. 14, 1949, and these photographs were taken on April 11, 1950.

In order not to get stuffy in our thinking, nature seems to throw in some extreme cases now and again to keep our minds elastic. Fig. 28 shows a case of excessive mandibular development for which there does not seem to be any

very obvious explicable reason. The condition of this case, however, was such that it was beyond the scope of orthodontics alone. This case was treated surgically by performing an osteotomy on the ascending rami which, together with some orthodontic therapy, produced a satisfactory occlusion.

Fig. 29 is another "unsatisfactory" occlusion which could be improved only by a combination of oral surgery and orthodontics. This case was treated by removing sections of the bone in the region of the molars and premolars on each side. The infradental nerve was cut in this case. The surgical work in both cases was done by Dr. James R. Cameron.

Dr. Cameron has performed quite a large number of operations of this kind and has found that sensation has always returned after a number of months.

The sole purpose of orthodontics is to obtain satisfactory clinical results. In the nature of things treatment should be based on a combination of broad general principles and the artistic imagination, inventive ingenuity, and mechanical strategy applicable to the unique factors of each individual case.

We are still looking for the genius who will devise a system which will include all of these requirements.

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Medical Arts Bldg.

CHANGES IN WIDTH DIMENSIONS BETWEEN CERTAIN TEETH AND FACIAL POINTS DURING HUMAN GROWTH

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I. REVIEW OF LITERATURE

JOHN HUNTER was one of the first men to study the growth of the jaws. He examined the bones of animals to which he had fed ground madder root and described the growth of the mandible with considerable accuracy. In the second edition of his book (1778) we read:

> The jaw still increases in all points till twelve months after birth, when the bodies of all six teeth are pretty well formed; but it never after increases in length between the symphysis and the sixth tooth; and from this time, too, the alveolar process, which makes the anterior part of the arches of both jaws, never becomes a section of a larger circle, whence the lower part of a child's face is flatter, or not so projecting forward as in the adult.

Brash (1928) used the same method as Hunter, namely, the feeding of ground madder to pigs. He came to the conclusion that in pigs there is growth at the alveolar border and also in the sockets of the teeth, causing movement of the teeth in an occlusal as well as in a buccal and mesial direction.

Hoffman and Schour (1940) made injections of alizarin red S (the active ingredient of madder) into rats. They made a quantitative as well as a qualitative study, and found that the path of eruption of the rat mandibular molars is in an occlusal, anterior, and lateral direction.

Sir Charles Tomes (1859) felt that the width dimension is stable at an even earlier age than did Hunter. He said that if transverse measurements were taken from the inner plate of the alveoli, between the first and second primary molars, at the level of the genioglossus muscle, there would be no change between birth and 9 months of age.

Colyer (1914) took measurements from 8 dried skulls between the ages of 3 months and 7 years and attempted to demonstrate growth changes.

Keith and Campion (1922) studied dried human skulls and came to the conclusion that there were 8 mm. of growth in width at the intermaxillary suture during the eruption of the permanent teeth.

Actual measurements of arches of the same individual during growth was first reported by Zsigmondy (1890). Later Tomes (1891), Wallace (1911, 1927), Chapman (1915), and Colyer (1920) reported similar serial measurements of arch widths.

This manuscript won second prize in the 1949 prize essay contest of the American Association of Orthodontists.

This thesis was submitted in partial fulfillment of the requirements for the degree of Master of Science in Orthodontics in the Graduate School of the University of Illinois in 1948. The author is assistant professor and acting head of the Department of Orthodontics at the University of Oregon Dental School.

In 1921 Franke measured 1,200 skulls and 150 models of jaws and published a quite complete study of jaw widths during growth.

Lewis and Lehman (1929) and Goldstein and Stanton (1935) made arch width measurements on large numbers of children with deciduous dentitions. Goldstein and Stanton (1937) followed up their previous study by relating their norms to cases exhibiting malocclusion.

Cohen (1940) reported on a longitudinal study of 28 children in which study casts were taken annually from 3½ years to 13½ years.

Studying skulls at the United States National Museum, Connolly (1928) found there was much variability in the breadth of the alveolar arches of various individuals, but that the averages for different races approximated each other closely in the corresponding age groups.

At the same time that width measurements of dental arches were being taken by the men just mentioned, others were taking width measurements of the face in general. In some cases these studies included measurements of the teeth. By taking measurements on skulls of ancient groups, it was found that the pattern of growth was the same and that the absolute sizes did not differ appreciably from normal growth in modern children. This fact was supported by the work of Krogman (1938), using skulls of children of ancient Iran dating to about 3000-2000 B.C., Hellman (1927) working on American Indian skulls dating back more than 2000 years, and Rittershofer (1937) studying Filipino skulls dating to the ninth or tenth century.

Growth of various facial widths during the prenatal period was studied by Scammon and Caulkins (1929).

The following authors presented tables giving mean facial widths at various ages: West (1894), Hellman (1932), Fleming (1933), Goldstein (1936), and Davenport (1940).

The work of Smyth and Young (1932) deserves special attention, because they took measurements similar to those used in this study. They made a cross-sectional study of English children with normal occlusion from 2 to 14 years of age. They took measurements of facial widths and also measured width between the first premolars and the first molars.

All of the authors who have reported on more than two or three cases have handled their data as though it were cross-sectional except Davenport (1940), although several of the men obtained their raw findings from longitudinal growth series. Shuttleworth (1937) gave a good review on the handling of growth data. He said that longitudinal data have no advantage over cross-sectional data for determining *average* size.

> The multitude of longitudinal studies which have yielded only cross sectional findings suggest that this faith has been degenerating to the level of pure dogma.

But he also stated that if the pattern of growth was essentially the same it would take only 10 or 20 cases studied *longitudinally* to determine that pattern. The advantage of longitudinal investigation is largely lost unless emphasis is placed on the individual, i.e., on the range of variation within the sample and on the growth behavior of dissimilar patterns.

II. METHOD AND MATERIAL

The method employed in this study, namely, serial cephalometric roentgenography, has been described many times previously. Briefly stated, the technique allows of the taking of frontal and lateral head roentgenograms which are exactly comparable to those taken of the same individual at other times. This is accomplished by maintaining a constant tube-patient-film relationship at all times. Frontal and lateral exposures are made in succession without permitting any movement of the head between exposures.

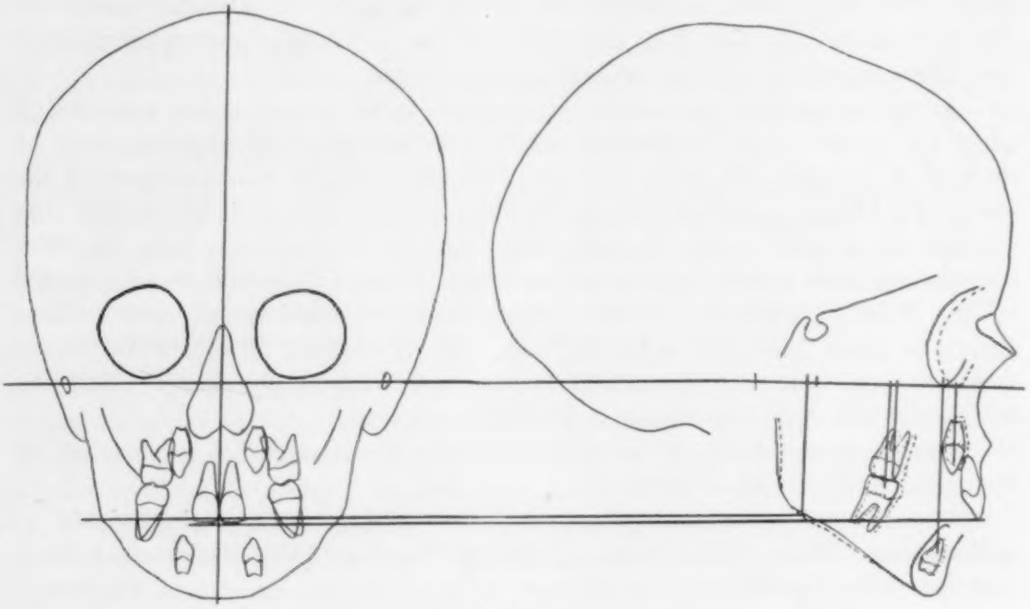


Fig. 1.

For the purpose of this study the corresponding lateral and frontal films were mounted on a transilluminated drafting board. The frontal film was placed to the left and, with a T-square, the right and left cephalometric porions were registered on a straight horizontal line and the film taped down. The lateral film was then placed to the right of the frontal with porion on a projection of the same line. The lateral cephalometric x-ray was rotated so that a projection of the tip of the upper central incisor on the lateral film would pass through the tip of the upper central incisor on the frontal film, after which the lateral film was securely taped down. The films were mounted in this fashion in order that points in the face could be projected from one film to the other or to a third plane of space according to accepted principles of drafting. Finally, a piece of Traceofilm paper was fastened over both films, the films were traced with a sharp pencil as in Fig. 1, and certain lines constructed. These will be described later.

The great majority of previous studies have employed the lateral film exclusively because it has not been possible to correct distortion in the frontal view until recently. A leaded aluminum millimeter scale placed at the mid-

sagittal plane when the exposure is made makes correction of the lateral film a simple matter because its image on the film is enlarged to the same degree as midline structures. Bilateral structures are reduced to the values of midline structures by halving the difference between them.

The correction of the frontal film poses difficulties not present in the lateral film. In this view the porionic axis is the base plane and it is always five feet from the anode. An object such as, for example, the upper canine is closer to the film surface than is the zygomatic arch. Therefore, the distance between the canines is enlarged less than that between the zygomatic arches. Further than this, as anteroposterior growth proceeds, the film surface is at a constantly increasing distance from the porionic plane, and hence even those parts that are not increasing in width throw larger shadows on the film. Thus there are found to be two variables in the frontal film that cannot be corrected by the same means as those employed for the lateral film.

DIAGRAMATIC REPRESENTATION OF WYLIE COMPENSATOR

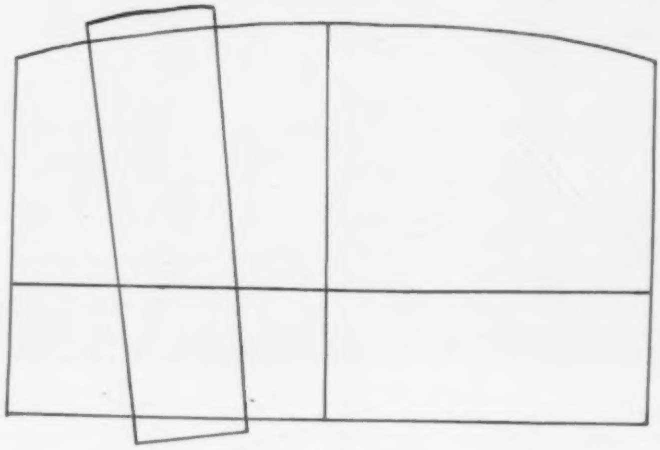


Fig. 2.

Wylie and Elsasser (1948) recently developed a cephalometric compensator to correct the errors in measurements on the frontal film (Fig. 2). The compensator is a piece of lucite with three straight sides forming three sides of a rectangle. Two lines perpendicular to each other and to the edges of the board are engraved on the lucite, crossing just below its center. The fourth side is an arc of a circle concentric to one with a five-foot radius which passes through the intersection of the two lines previously mentioned. This point represents the intersection of the midsagittal and porionic planes of the head and the point of intersection of the lateral and frontal axis rays. A slider similar to a T-square but with its bearing edge cut to form an arc of the same size fits this side. The edges of the slider form radii of a five-foot circle when the slider is held firmly against the arc on the compensator. Because the cephalometric x-rays are taken at a five-foot distance from x-ray tube to porionic axis, the side of the slider on the compensator (Fig. 3), placed at any anatomical

landmark, represents the path followed by the roentgen rays going through that part.

To correct measurements on the frontal cephalometric film, it is necessary to trace both the frontal and lateral films, because only from the lateral film is it possible to measure the distances between the transporionic axis and the various facial landmarks. It will be recalled that in the making of the two exposures in the Broadbent-Bolton apparatus, the patient's head is oriented in the Frankfort horizontal position and that the axis rays of the two tubes travel in this plane. When the films are placed on the tracing table they are both oriented to a common Frankfort plane and this becomes the plane of reference for both films. To measure the distance between any landmark and the frontal plane traveling through porion, it is only necessary to erect a perpendicular from such a landmark to the Frankfort plane and measure from the point of intersection to porion with a correctional scale (see Fig. 1).

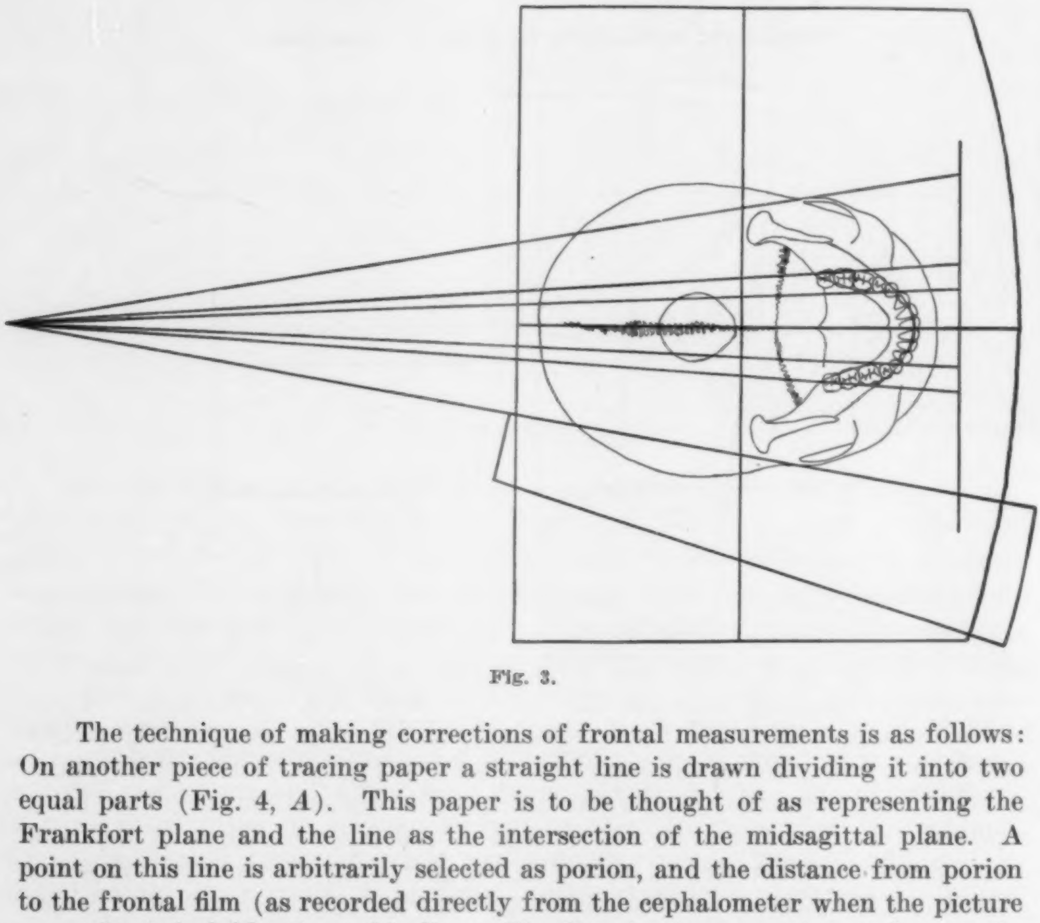
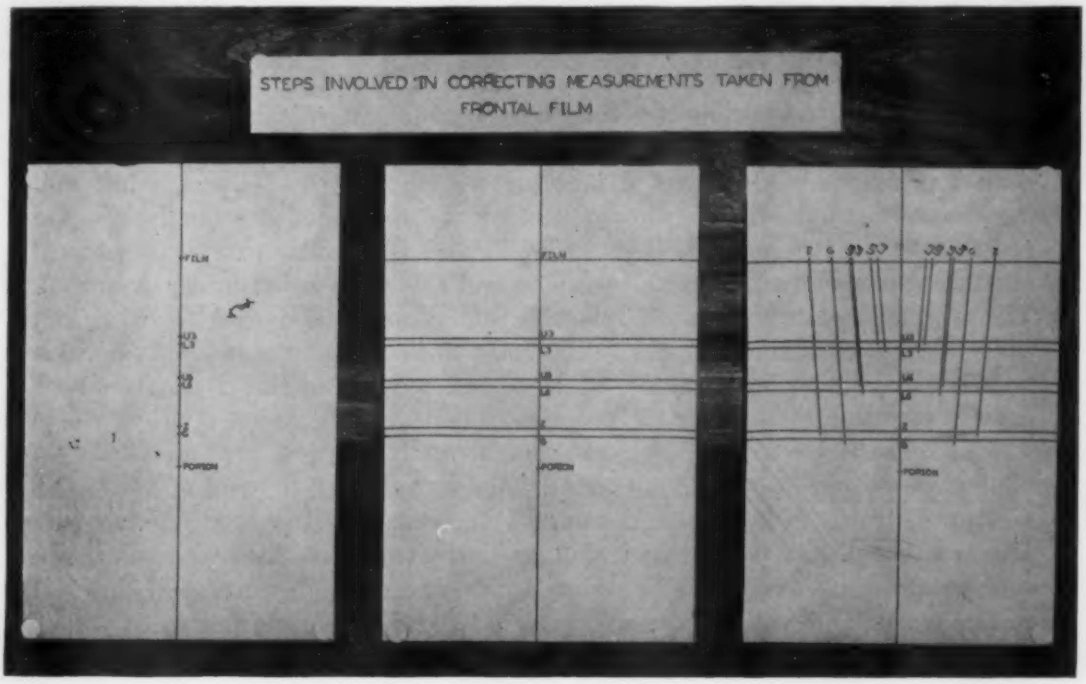


Fig. 3.

The technique of making corrections of frontal measurements is as follows: On another piece of tracing paper a straight line is drawn dividing it into two equal parts (Fig. 4, *A*). This paper is to be thought of as representing the Frankfort plane and the line as the intersection of the midsagittal plane. A point on this line is arbitrarily selected as porion, and the distance from porion to the frontal film (as recorded directly from the cephalometer when the picture was taken) is laid off on this line. The line is then superimposed over the Frankfort horizontal line on the lateral film tracing, and the porion points are made to coincide. The points representing the projections to Frankfort horizontal are transferred to the second paper and it is from these that the measure-

ments will be taken. This paper is now taken to the cephalometric compensator and taped down in such a manner that the line coincides with the vertical line of the compensator and the point representing porion on the paper registers exactly over the intersection of the two engraved lines on the lucite. With a T-square, a line is drawn through the point representing the film. Lines are similarly drawn through the various points that have been previously transferred to this line (Fig. 4, *B*).



A. *B.* *C.*

Fig. 4.

The tracing paper is now removed from the compensator and the various widths are read from the original tracing and laid off on the line representing the film. This is done by placing the film line between various widths, maintaining the vertical registration of line with the midsagittal plane. This paper is then placed on the cephalometric compensator as before. With the slider, a line is drawn from each of the points on the film line to its corresponding transverse line, previously layed off (Fig. 4, *C*). True widths are now determined by measuring the distance between the right and left intersections of a given character.

For the purpose of this study the upper and lower permanent canines and the upper and lower permanent first molars were located on both lateral and frontal x-rays. The gonial region of the mandible was traced and the actual gonion located on the frontal film and transferred to the lateral film. The cross section of the zygoma was located on the frontal film, but in the lateral film it was impossible to tell which was the widest point of the zygoma. Consequently, the projection at the junction of the anterior root with the zygomatic process,

which acts as an attachment for the temporomandibular ligament, was arbitrarily selected. Wherever the right and left objects were seen on the lateral film a mean point between the two was selected. The widest point of the teeth on the lateral film was chosen as the mean point between the mesial and distal surfaces. On the frontal film the widest point of the crowns of the teeth, wherever found, was used.

The method was checked for accuracy in the following manner: Ten skulls were oriented in the Broadbent-Bolton cephalometer and lateral and frontal cephalometric x-rays obtained. Each pair of roentgenograms was then traced in the usual manner and the measurements were corrected, as described previously, with the cephalometric compensator and recorded. These measurements were laid aside and the same measurements were taken directly from the skulls with head spanning dividers. Certain measurements taken at the beginning of the study revealed inaccuracies too large to be acceptable, and these were eliminated. The comparison of the measurements finally used as revealed by the two methods is shown in Table I. Measurements were made of all dimensions on two separate occasions and these are listed under A and B. The original measurements (A) showed rather large differences at times, but these were of a distinctly random character and indicated a lack of precision on the part of the investigator. The second measurements (B), taken with greater attention to accuracy, failed to show marked differences.

The material consisted of lateral and frontal x-rays of 28 individuals, 14 male patients and 14 female patients, beginning at about 3 years of age, taken semiannually up to 5 years and annually thereafter to 15 years. Twenty-five of the patients had normal occlusion or untreated Class I malocclusion; one case was an untreated Class II malocclusion; one case, an untreated Class III malocclusion; and one was a case of treated Class I malocclusion.

III. FINDINGS

The raw data upon which this study is based are exhibited in Tables II to VII. The measurements are recorded for each individual at each age period. A few films were missing from the various series, and consequently those spaces were left blank. The first 14 were male patients; the last 14 were female patients. The pattern of growth in the areas studied was shown to be uniform, although absolute sizes varied considerably.

Table VIII shows the mean facial measurements for each age, and it will be noted that the mean measurements for the two dimensions studied are smaller in the female patient than in the male patient. Exceptions are found, however, in Case 2629 (female) which is one of the largest in all measurements; and in Case 2005 (male) which is considerably below the mean measurement of the female in most respects.

Bizygomatic width (Fig. 5) increases at the slowly decreasing rate characteristic of other facial dimensions. The bizygomatic width in girls follows a course similar to that of the boys, except that it is smaller. Beginning between the tenth and eleventh years, it increases slightly so that it approaches the male level until the thirteenth year, when the male once more goes ahead. This is probably due to the difference in onset of adolescence.

TABLE I. COMPARISON OF MEASUREMENTS MADE DIRECTLY AND WITH WYLIE COMPENSATOR

SKULL	BIMASTOID A	BIMASTOID B	BIGONIAL A	BIGONIAL B	BIZYGOMATIC A	BIZYGOMATIC B	BIORBITAL A	BIORBITAL B	WIDTH 6 | 6 A	WIDTH 6 | 6 B	WIDTH 3 | 3 A	WIDTH 3 | 3 B	NASAL WIDTH A	NASAL WIDTH B
No. 1														
Direct	98.5	97.5	106.0	104.0	136.0	136.0	104.5	104.0	64.0	64.0	40.5	40.5	30.0	28.5
Compensator	97.0	97.5	104.0	104.0	136.0	136.0	98.5	100.0	59.5	64.0	40.5	40.0	25.0	28.5
No. 2														
Direct	90.5	92.0	80.5	80.0	114.5	114.5	90.5	89.0	53.5	53.5	33.5	34.0	23.5	23.0
Compensator	93.0	92.0	80.0	79.0	113.5	114.5	88.0	88.5	53.5	53.0	33.0	33.5	23.0	23.0
No. 3														
Direct	99.5	99.0	88.5	88.0	117.5	118.0	93.5	94.5	54.0	54.0	37.0	37.5	27.5	26.0
Compensator	99.5	98.0	87.5	88.0	118.0	118.0	92.0	91.0	53.5	54.0	37.5	37.0	25.0	26.0
No. 4														
Direct	106.0	107.0	107.0	107.0	124.0	124.0	94.5	94.5	57.5	57.5	39.5	39.0	25.0	24.5
Compensator	109.0	108.0	108.0	107.0	122.5	123.5	88.0	88.5	58.0	57.5	34.0	39.0	24.0	24.5
No. 5														
Direct	102.5	102.0	107.0	107.0	137.0	137.5	100.0	99.5	63.0	62.5	41.5	41.5	23.5	24.0
Compensator	102.0	102.0	107.0	107.0	136.5	138.0	97.5	99.0	57.0	57.5	41.5	41.5	24.5	24.0
No. 6														
Direct	101.0	101.0	90.5	90.0	122.0	122.0	93.5	93.0	56.0	56.0	39.0	39.0	25.0	26.0
Compensator	101.0	101.0	87.5	89.0	121.0	122.0	94.0	91.0	55.0	55.5	39.5	39.0	27.0	26.0
No. 7														
Direct	100.5	98.5	95.0	94.5	122.0	121.5	88.5	88.0	59.0	59.0	37.5	37.5	25.0	24.0
Compensator	99.5	99.5	93.5	94.0	122.0	122.5	87.0	86.0	58.0	58.0	36.0	37.0	23.0	23.0
No. 8														
Direct	103.0	103.0	95.0	94.5	125.0	125.0	89.0	88.0	62.5	62.0	41.0	41.0	24.0	23.0
Compensator	103.0	105.0	94.0	94.5	119.5	125.0	86.0	88.0	61.5	62.0	41.0	40.5	24.5	24.5
No. 9														
Direct	89.0	88.0	83.0	82.5	105.0	105.0	82.5	82.0	52.5	52.0	35.0	35.0	22.0	20.5
Compensator	87.5	88.0	81.5	82.5	104.0	104.0	79.0	80.5	52.0	51.5	35.0	35.5	20.0	19.5
No. 10														
Direct	93.0	92.5	81.5	80.5	111.5	111.5	89.0	88.0	56.5	56.5	40.0	39.0	22.0	21.5
Compensator	93.0	92.0	79.0	80.5	106.5	109.0	84.0	85.5	56.0	56.5	39.0	39.0	22.0	21.5

TABLE II. AGE CHANGES IN BIZYGOMATIC WIDTH

AGE CASE	2/6/0	3/0/0	3/6/0	4/0/0	4/6/0	5/0/0	6/0/0	7/0/0	8/0/0	9/0/0	10/0/0	11/0/0	12/0/0	13/0/0	14/0/0	15/0/0	16/0/0
1932		103.0	104.5	105.5	108.0	109.0	110.0	111.0	114.0	114.0	118.0	118.5	121.0	121.5			130.0
2049			105.0	106.0	107.0	108.0	108.0	111.0	110.5	113.0	114.0	116.0	116.5	117.5		119.5	
2035		101.5	103.5	104.0	106.5	106.0	107.5	109.5	110.5	111.0	114.5	115.5	116.5	118.0	119.5	124.0	
1186			98.5			107.5	109.5	112.0	114.0	114.5	116.0	118.5	118.5	121.5	124.0		129.0
2321	100.0			106.0	107.0	108.0	111.0	111.0	111.5	113.0	115.0	117.0	117.0	118.5	123.0	125.0	
2058		98.0	103.0		105.0	107.0	111.5	109.0	110.5	113.0	114.0	116.5	117.5	118.5	119.0	123.5	
2285	94.0	94.0	95.0	98.0	100.0	102.0	103.0	106.0	107.5	108.0	110.5	111.5	114.0	114.5	118.0	120.5	
2070		104.0	107.0	108.0	110.0	110.5	112.5	112.5	114.0	115.0	117.5	119.0	121.0	122.0	125.5	127.5	
2791		101.0	102.0	102.0	103.0	103.0	107.0	107.0	109.5	110.0	113.0	112.5	114.5	115.0	117.0	118.51	
2413	102.5	104.0	105.0	106.5	107.5	108.5	110.0	111.0	113.5	115.0	116.0	118.0	120.0	123.0	124.0	126.0	
2905		103.0	103.0	103.5	106.0	106.0	108.5	110.0	113.0	114.0		118.0	118.0	120.0	124.0	128.5	
2138	96.0		105.0	107.0	108.5	108.5	110.0	113.0	113.5	115.5	117.5	118.0	121.0	123.0	124.5	129.0	
1937		106.0	107.0	106.5		112.5	113.5	116.5	118.0	118.0	119.5	121.0	123.0	126.5	126.0	130.0	
2005	96.0	97.0	99.0	101.5	103.0	104.0	105.0	107.0	111.0	110.5	114.5	115.0	115.5	120.0		124.5	
A. B.		92.5	99.5	96.5		95.5	101.0	102.0	104.5	106.0	108.0	110.0	113.5	112.5	114.5	115.0	116.5
112		100.0	103.0	104.0	104.0	106.0	109.5	111.0	112.5	114.5	114.0	116.0	118.0	118.0	120.0	121.0	
2183	98.0	99.5	102.5	102.5	103.5	107.0	106.0	109.0	110.5	113.0	114.0	116.5	120.0	121.0	123.5	124.5	
2457		101.5	101.5	103.5	104.5	105.0	105.0	106.5	108.5	110.5	112.5		115.5	118.5	119.0	120.0	
2462	97.0	100.0	100.0	103.0	103.0	104.0	105.5	108.5	110.0	113.5	114.5	118.5	119.0	121.5	121.5	122.5	
2507		98.0	100.5	101.0	102.5	102.0	104.5	107.0	108.5	109.0	112.0	114.0	117.0	118.0	119.0	120.0	
2203		96.5	99.5	99.5	101.5	102.0	104.0	104.5	107.0	107.5	111.0	111.5		115.5	116.5	118.0	
1983		99.5	102.5	103.5		106.5	107.5	109.0	110.0	111.5	113.0	117.0	118.5	121.5	121.5	122.5	
2357	97.0	100.0	104.0	106.0	107.0	108.5		111.0	113.0	114.5	117.0	118.5	122.0	122.5	123.5	123.0	
1257		96.0	100.0	101.5	102.0	101.0	106.0	110.0	110.5	107.5	109.0	110.5	112.0	113.0	115.0	116.5	
1916	92.0	94.0	97.0	98.0	101.5	101.0	102.0	103.5	105.0	106.0	108.0	111.5	113.0	114.0	116.5		116.5
2407		96.0	100.0	101.5	102.0	103.0	104.0	105.0	107.0	108.0	110.0	111.0	114.5		118.5		118.5
2030	97.0	98.5	99.0	101.0	101.5	104.0	106.0	106.0	108.0	110.5	113.0	115.0		116.0	116.5	116.0	
2629		103.5	106.0	107.5	109.5	109.0	111.5	116.0	116.0	118.0	121.0	124.0	124.0		128.0	128.0	

TABLE III. AGE CHANGES IN BIGONIAL WIDTH

AGE CASE	2/6/0	3/0/0	3/6/0	4/0/0	4/6/0	5/0/0	6/0/0	7/0/0	8/0/0	9/0/0	10/0/0	11/0/0	12/0/0	13/0/0	14/0/0	15/0/0	16/0/0
1932		65.5	68.0	67.5	68.5	71.0	73.0	74.5	76.5	78.5	79.5	81.0	81.5	82.0			87.5
2049			73.0	74.0	75.5	77.0	76.5	80.0	80.5	83.0	84.0	85.5	87.0	87.5		89.5	
2035		75.0	78.0	78.0	80.0	81.0	83.5	84.0	87.5	88.0	90.0	92.5	94.0	92.5	96.5	98.0	
1186			72.0			75.0	78.0	79.0	81.5	82.0	83.0	85.0	86.0	89.5	90.5		96.0
2321	71.0			77.0	78.0	80.5	81.5	82.5	84.0	86.0	87.5	90.0	90.5	92.0	94.0	97.0	
2058		71.5	76.0		77.5	80.0	80.0	82.0	84.0	85.5	87.0	88.0	91.0	92.0	93.5	95.5	
2285	66.0	68.0	69.0	71.5	72.0	74.0	75.5	78.5	81.0	82.5	84.0	86.0	86.5	88.0	91.0	93.0	
2070		71.0	71.0	72.0	74.5	74.5	77.0	77.5	80.0	81.5	83.5	85.0	86.0	87.0	91.5	93.0	
2791		71.0	71.5	73.0	74.0	74.0	77.5	79.0	81.5	81.5	83.0	83.5	84.0	85.0	86.5	87.0	
2413	74.0	75.5	75.5	77.5	79.0	81.0	80.0	83.5	84.0	87.0	87.0	88.5	89.5	92.0	94.0	96.0	
2905		72.5	71.0	71.0	72.0	71.5	74.0	75.5	79.0	81.0		82.0	83.5	86.5	88.5	91.5	
2138	69.5		74.0	74.5	76.5	77.5	79.0	82.0	83.0	84.5	85.5	87.0	87.5	89.5	94.0	97.0	
1937		73.5	76.0	75.0		80.0	81.5	83.5	84.5	86.5	87.0	89.0	90.5	93.0	93.5	95.0	
2005	65.0	66.0	67.5	68.5	69.5	72.0	71.0	73.0	76.0	77.0	78.5	78.5	81.0	83.0		86.5	
A. B.		65.5	68.0	67.0		67.5	71.0	72.0	75.5	76.5	78.0	79.5	82.0	81.0	83.0	82.5	85.0
112.0		66.5	69.0	69.5	69.5	72.0	74.0	76.0	77.5	78.0	78.5	80.0	82.0	82.0	83.5	84.0	
2183	65.5	67.5	68.5	70.0	70.0	71.5	72.5	75.0	75.0	77.5	78.0	80.0	81.0	83.0	84.0	85.5	
2457		69.0	70.0	71.5	72.0	73.5	75.0	77.0	80.0	81.0	83.5		86.5	88.5	89.5	90.5	
2462	66.0	69.0	70.0	72.5	72.0	73.0	72.5	75.5	76.0	79.5	80.0	83.0	83.5	84.5	83.0	83.0	
2507		70.5	72.0	73.0	75.0	74.5	78.0	79.5	82.5	82.0	86.0	86.0	87.5	90.0	90.5	91.0	
2203		70.5	71.5	72.5	73.0	74.5	75.5	79.0	81.0	82.0	83.5	85.5	85.5	88.0	89.0	90.0	
1983		71.5	74.0	74.5		77.0	79.0	79.5	81.0	82.5	83.0	85.5	87.0	87.0	87.5	89.0	
2357	68.0	69.5	73.5	77.0	76.5	80.0		82.0	85.5	87.0	88.5	90.5	91.5	91.0	92.0	92.0	
1257		68.5	70.0	72.5	74.5	74.0	76.5	78.0	80.5	81.0	83.5	84.0	84.0	85.0	87.5	88.0	
1916	63.5	64.0	65.0	66.5	68.5	69.5	69.5	71.0	73.0	74.0	76.0	77.0	79.5	81.0	83.0		85.0
2407		69.0	69.5	71.5	74.0	74.5	76.0	77.5	79.5	81.0	81.5	82.0	85.0		89.0		88.0
2030	67.0	68.0	70.0	70.5	73.0	74.5	75.5	76.0	77.5	79.5	80.0	82.5		82.5	83.0	82.0	
2629		75.5	77.0	78.0	80.0	80.0	83.0	84.0	86.0	87.5	90.0	92.0	93.5		95.0	95.0	

TABLE IV. AGE CHANGES IN UPPER INTERCANINE WIDTH

AGE CASE	2/6/0	3/0/0	3/6/0	4/0/0	4/6/0	5/0/0	6/0/0	7/0/0	8/0/0	9/0/0	10/0/0	11/0/0	12/0/0	13/0/0	14/0/0	15/0/0	16/0/0
1932		29.0	30.5	29.5	31.0	32.0	32.0	34.0	34.0	33.5	34.5	33.5	34.5	35.0			36.0
2049			32.0	32.5	30.5	34.0	33.5	36.5	36.5	36.0	33.5	33.5	38.0	40.5		41.5	
2035		32.5	33.0	30.0	32.0	34.0	35.0	34.0	37.0	34.5	31.5	30.5	29.0	30.0	31.0	30.5	
1186			32.5			34.5	36.0	37.5	37.0	36.0	34.5	35.5	33.0	36.0	39.0		43.0
2321	33.0			33.5	33.0	34.0	35.5	34.0	36.0	36.0	33.5	34.0	37.0	41.0	40.5	41.5	
2058		29.5	33.0		34.5	35.0	32.5	33.0	34.5	34.0	34.0	33.0	34.0	38.5	37.5	39.0	
2285	30.0	30.0	30.0	29.0	32.0	34.0	35.5	35.5	35.5	34.0	34.5	34.0	35.0	38.5	41.5	39.5	
2070		30.5	34.0	37.0	37.5	38.0	38.5	38.5	36.5	35.0	34.5	36.0	38.5	39.0	39.0	38.5	
2791		32.0	34.0	34.0	32.0	34.5	36.0	36.0	38.0	37.0	35.0	34.0	33.5	36.0	39.0	40.0	
2413	30.0	32.5	34.0	34.0	34.0	33.0	33.0	34.0	33.0	31.0	31.5	33.0	33.5	37.5	38.0	38.0	
2905		31.0	34.0	33.5	34.5	34.5	35.0	35.0	33.5	33.0		37.5	38.0	38.5	39.0	39.5	
2138	32.0		33.0	34.0	35.0	35.0	35.5	36.0	34.5	33.5	35.5	38.0	38.0	39.0	38.5	39.0	
1937		31.0	30.5	30.5		35.0	34.5	37.0	34.5	34.0	36.0	38.0	40.0	41.5	41.0	41.0	
2005	30.0	31.0	30.0	30.0	31.0	32.0	31.0	31.0	30.0	30.0	32.0	35.0	36.0	37.0		35.5	
A. B.		33.0	32.5	32.5		32.5	33.5	34.5	34.5	32.0	31.5	33.0	37.0	37.5	38.5	38.0	38.5
112		30.0	32.0	33.0	33.0	33.0	33.0	34.5	34.0	32.0	31.0	32.0	34.0	35.0	37.0	38.0	
2183	27.5	31.5	33.0	32.0	32.0	33.5	34.0	34.0	32.0	31.0	31.0	35.5	38.0	36.0	37.5	37.5	
2457		31.0	34.0	33.0	33.5	36.5	35.0	36.5	35.0	33.0	33.5		37.5	39.5	38.0	37.5	
2462	29.0	30.5	29.0	20.5	31.5	30.0	32.0	33.5	31.0	29.5	31.0	36.5	35.5	36.0	37.0	37.5	
2507		31.0	32.5	36.0	36.0	37.0	37.0	35.5	32.5	35.0	34.5	35.5	39.0	41.0	40.0	40.0	
2203		28.5	30.5	32.0	30.5	32.5	33.0	34.0	34.0	35.0	38.0	38.0		38.5	37.5	37.5	
1983		31.5	31.5	33.0		33.5	33.0	31.5	30.0	32.0	31.5	37.5	37.5	37.0	36.0	36.0	
2357	28.5	28.0	31.5	33.0	30.0	33.0		33.5	35.0	34.0	32.5	35.0	38.5	39.5	37.5	37.5	
1257		31.5	32.0	31.0	32.0	31.0	32.0	33.5	34.0	33.0	33.5	33.0	37.0	38.5	39.0	38.0	
1916	27.5	28.0	31.0	30.5	30.5	31.0	30.5	31.0	30.0	28.5	27.5	31.0	33.5	34.0	34.0		34.5
2407		30.0	32.0	31.5	32.5	33.0	32.5	30.5	32.0	32.0	37.0	36.5	38.5		38.5		36.5
2030	32.0	33.0	33.0	31.5	35.0	36.5	36.5	35.4	34.5	38.0	39.0	40.0		38.5	40.0	40.0	
2629		31.0	30.0	32.5	31.5	35.0	37.0	36.0	36.5	36.0	37.5	42.0	42.0		42.0	42.0	

TABLE V. AGE CHANGES IN LOWER INTERCANINE WIDTH

AGE / CASE	2/6/0	3/0/0	3/6/0	4/0/0	4/6/0	5/0/0	6/0/0	7/0/0	8/0/0	9/0/0	10/0/0	11/0/0	12/0/0	13/0/0	14/0/0	15/0/0	16/0/0
1932		31.0	31.0	31.0	31.5	31.0	30.5	30.0	29.0	28.0	29.0	30.0	31.0	31.0			30.0
2049			33.0	33.0	33.0	32.5	32.0	32.5	30.0	29.0	29.0	29.0	33.5	33.0		32.5	
2035		33.5	33.5	32.5	32.5	32.0	32.0	31.0	30.5	29.0	29.0	29.0	29.0	30.0	31.0	30.5	
1186			31.0			33.0	34.0	33.5	33.0	30.5	28.5	27.0	27.0	29.0	33.0		32.5
2321	31.0			32.0	32.0	33.0	33.0	32.0	31.5	29.5	28.5	29.5	32.0	32.5	33.0	33.0	
2058		30.5	30.5		30.5	30.0	29.5	29.0	28.0	27.0	29.0	29.5	31.0	30.0	30.5	30.0	
2285	30.0	29.5	30.0	30.5	30.5	30.0	30.0	30.5	28.5	27.0	26.5	27.5	30.5	30.0	30.0	30.0	
2070		30.0	30.5	30.0	30.0	29.5	28.5	27.0	26.5	26.0	29.5	30.0	30.0	30.0	30.5	30.0	
2791		30.0	30.5	30.5	30.5	30.5	30.0	29.5	29.0	29.0	29.5	30.5	31.0	31.5	31.5	31.5	
2413	31.0	31.5	32.0	32.0	32.0	31.5	31.0	30.5	29.0	29.0	30.5	30.5	30.5	29.5	29.5	30.5	
2905		27.5	28.5	28.0	28.5	28.5	28.0	26.0	25.0	26.5		30.0	30.5	31.0	31.0	31.0	
2138	31.0		32.0	32.0	32.0	32.0	31.0	29.5	28.0	29.0	32.0	32.5	32.0	32.5	32.5	33.0	
1937		31.0	31.0	30.5		31.0	31.0	30.5	28.5	28.5	33.5	31.5	31.5	31.5	31.5	31.5	
2005	27.0	27.0	27.5	28.0	27.5	27.0	26.5	26.0	26.0	28.0	30.0	29.5	29.5	29.0		29.0	
A. B.		29.5	29.5	29.5		29.5	29.0	29.5	28.0	28.0	29.0	20.0	31.0	30.5	30.5	30.0	30.5
112		30.0	30.5	30.0	29.5	30.0	29.5	27.5	25.0	24.0	24.5	30.0	31.0	33.0	33.0	34.0	
2183	28.0	28.0	28.5	28.5	28.5	29.0	28.5	28.0	26.0	26.0	28.0	29.0	30.0	30.0	29.0	29.0	
2457		30.0	30.5	30.5	30.5	30.5	29.0	27.0	24.5	23.5	23.5		29.0	29.0	28.5	28.5	
2462	28.5	29.0	29.0	29.0	29.0	29.5	27.5	27.0	26.0	25.0	29.5	29.5	29.0	29.0	29.5	29.5	
2507		33.0	32.5	33.0	33.0	32.0	31.5	31.0	29.0	27.5	27.5	29.5	31.0	31.0	30.5	30.0	
2203		29.0	29.5	29.0	29.0	29.5	29.0	28.0	28.5	30.0	30.0	29.0	29.0	29.0	28.5	30.0	
1983		30.5	31.0	31.5		31.0	30.0	27.0	24.5	26.0	29.0	30.0	30.0	29.5	29.5	29.5	
2357	29.5	29.5	30.0	30.0	30.0	30.0		28.5	27.0	28.0	30.5	30.0	31.0	31.0	30.5	30.5	
1257		27.5	27.5	28.0	28.5	28.5	28.5	28.5	28.5	27.0	27.5	20.0	29.5	29.5	29.0	29.0	
1916	26.0	26.5	27.0	26.5	26.5	26.5	25.0	24.5	22.5	23.0	25.0	27.0	28.5	28.0	29.0		28.0
2407		28.5	28.5	28.5	28.0	28.5	26.0	25.0	26.5	28.5	30.0	29.0	30.0		30.0		29.5
2030	33.0	33.0	33.0	33.0	33.0	33.0	32.5	30.0	29.5	32.0	32.0	32.0		32.5	32.5	32.0	
2629		32.0	32.0	32.0	32.0	31.0	31.0	30.5	30.5	31.5	31.5	33.0	32.0		32.5	31.5	

TABLE VI. AGE CHANGES IN UPPER FIRST MOLAR WIDTH

AGE / CASE	2/6/0	3/0/0	3/6/0	4/0/0	4/6/0	5/0/0	6/0/0	7/0/0	8/0/0	9/0/0	10/0/0	11/0/0	12/0/0	13/0/0	14/0/0	15/0/0	16/0/0
1932		52.0	53.0	53.0	54.0	53.5	53.0	54.0	56.0	56.0	56.5	56.5	56.5	56.0			55.0
2049			54.5	55.5	55.0	55.5	56.0	56.5	56.5	57.5	57.5	57.5	58.0	58.5		59.0	
2035		51.0	52.0	52.0	52.0	52.0	53.0	54.0	55.5	55.5	58.0	57.0	57.0	55.0	58.0	58.0	
1186			49.0			52.0	52.5	55.0	58.0	58.0	58.0	59.0	59.0	60.0	61.0		59.5
2321	51.0			53.0	54.0	53.5	53.5	54.0	54.5	56.0	56.0	56.0	57.0	58.5	59.0	59.0	
2058		52.0	53.5		54.0	53.0	53.5	55.0	56.5	56.5	57.5	57.5	58.0	58.0	58.0	59.0	
2285	49.5	49.5	49.5	50.5	50.5	50.0	51.0	53.0	53.5	54.0	54.0	54.5	55.0	55.0	55.0	55.5	
2070		53.5	54.5	54.0	54.5	55.0	56.0	57.0	58.0	58.0	58.0	59.5	59.5	59.0	60.0	60.5	
2791		52.5	53.0	53.0	53.0	53.0	53.5	55.5	57.5	57.5	57.5	57.0	57.0	57.0	56.0	55.5	
2413	53.5	54.0	54.0	54.5	54.0	54.0	53.0	54.0	54.5	54.0	54.0	54.0	55.0	55.0	54.0	53.5	
2905	50.0		51.0	50.0	51.0	52.0	53.5	53.0	54.0	55.0		55.0	55.5	56.0	56.5	56.5	
2138	49.5		50.5	50.5	51.0	51.5	51.5	52.5	53.0	54.0	54.5	55.0	56.0	56.5	57.5	57.5	
1937		51.5	51.5	52.0		54.0	56.0	58.0	58.5	58.0	58.0	58.5	58.5	58.5	58.5	58.5	
2005	46.0	45.5	46.5	47.0	48.0	48.0	49.0	50.0	50.5	50.5	50.0	49.5	49.5	51.5		51.0	
A. B.		45.0	46.0	46.0		47.0	48.5	50.5	51.0	52.0	53.0	53.5	54.5	54.0	54.5	54.5	54.5
112		47.5	48.5	50.0	50.0	51.0	52.0	54.0	56.0	56.5	57.0	57.5	57.5	55.5	58.0	58.0	
2183	48.5	50.0	50.0	51.5	51.0	52.0	50.5	53.0	53.5	53.0	53.5	54.0	53.0	54.0	53.5	54.0	
2457		51.0	52.0	52.5	52.0	53.0	52.5	54.0	54.0	54.0	55.0		55.5	56.5	55.5	55.5	
2462	47.0	48.0	48.0	48.0	48.0	49.5	50.0	52.0	53.0	54.0	54.0	55.0	54.5	55.0	54.5	54.5	
2567		51.0	52.0	53.0	54.0	53.5	54.0	56.0	57.0	57.5	57.0	57.0	57.0	58.0	58.0	57.5	
2203		48.0	49.0	50.0	51.0	51.0	51.0	52.0	52.5	53.0	53.0	54.0		54.0	52.5	53.0	
1983		52.0	54.0	53.5		53.0	53.0	53.0	53.0	53.0	53.0	53.5	53.5	53.5	53.5	53.5	
2357	49.0	50.0	50.5	52.0	52.0	52.0		53.5	53.5	55.0	56.0	56.0	57.5	57.0	55.5	57.0	
1257		49.0	50.0	50.5	51.0	51.0	52.5	53.5	54.5	54.5	54.5	54.5	55.0	56.0	55.5	56.0	
1916	47.0	47.0	48.0	48.0	48.5	49.0	50.0	51.0	52.0	50.5	51.5	52.0	52.0	52.0	52.0		52.0
2407		48.0	48.0	49.0	49.0	50.0	52.0	52.0	53.0	53.0	54.5	54.0	54.0		54.5		53.5
2030	47.5	49.0	49.5	50.5	51.0	52.5	55.0	55.0	55.0	56.0	56.0	57.0		57.0	57.0	56.5	
2629		55.0	55.5	55.5	55.5	54.5	56.0	57.0	57.5	58.0	58.5	59.0	59.0		59.0	59.5	

TABLE VII. AGE CHANGES IN LOWER FIRST MOLAR WIDTH

AGE / CASE	2/6/0	3/0/0	3/6/0	4/0/0	4/6/0	5/0/0	6/0/0	7/0/0	8/0/0	9/0/0	10/0/0	11/0/0	12/0/0	13/0/0	14/0/0	15/0/0	16/0/0
1932		64.5	64.5	63.5	63.5	63.0	59.5	56.5	56.0	56.0	56.5	56.5	56.5	56.0			
2049			66.5	66.0	65.0	64.0	59.5	56.5	56.0	56.5	56.0	56.5	56.0	55.5		54.5	
2035		65.0	64.0	63.0	62.5	60.5	58.0	56.0	55.5	55.5	56.0	56.0	56.0	54.5	57.0	57.0	
1186			64.0			65.0	64.0	61.5	58.0	57.0	56.0	57.0	57.0	57.5	58.5		58.0
2321	64.5			66.0	65.5	65.5	64.0	60.0	57.0	56.5	56.5	56.5	57.0	58.5	59.0	59.0	
2058		63.5	64.0		62.0	61.5	55.0	55.0	55.0	55.5	55.0	55.5	55.5	55.0	55.0	55.0	
2285	60.0	59.0	57.5	57.0	57.0	56.0	54.0	53.0	51.5	52.5	53.0	53.5	53.5	53.0	53.0	53.0	
2070		63.0	62.0	61.0	59.0	58.0	54.0	54.5	55.0	55.5	56.5	56.0	59.5	59.0	60.0	60.5	
2791		65.0	64.5	63.5	61.5	61.0	58.5	56.0	55.5	55.0	55.0	54.0	54.0	54.0	53.0	52.5	
2413	67.0	67.0	65.5	65.0	64.0	63.5	59.0	57.0	55.5	54.5	54.0	53.0	53.5	53.5	52.0	52.0	
2905		63.5	62.5	59.5	58.5	53.5	53.5	53.0	53.0	53.5		53.5	53.5	54.0	53.5	55.0	
2138	63.0		63.0	62.0	61.5	60.0	55.0	54.5	54.5	54.5	54.5	55.0	56.0	56.5	57.0	56.5	
1937		65.5	65.0	63.0		63.0	58.0	57.0	55.5	55.5	55.0	56.0	56.5	55.0	56.5	56.5	
2005	57.0	57.0	57.0	55.5	55.0	54.0	51.0	50.0	50.0	49.0	50.0	49.5	49.5	50.0		50.5	
A. B.		62.0	61.5	60.0		58.5	57.0	54.5	53.5	54.0	53.0	53.5	54.5	54.0	54.0	54.0	53.0
112		63.0	63.0	62.0	60.5	60.5	60.0	58.0	56.0	56.0	56.0	56.0	56.0	54.5	56.0	56.0	
2183	62.0	61.5	61.0	60.0	59.5	59.5	54.5	52.0	52.0	52.5	52.0	52.0	51.5	51.0	52.5	51.0	
2457		62.5	62.5	60.5	59.5	59.5	57.0	54.0	53.0	53.0	53.5		52.5	54.0	52.0	52.5	
2462	61.5	61.5	61.5	61.0	60.0	56.0	56.0	54.5	53.5	53.0	53.0	53.0	52.0	52.0	51.5	51.5	
2507		64.0	62.5	62.5	62.0	60.5	58.5	57.0	56.0	55.5	55.5	55.0	55.0	54.0	53.0	53.0	
2203		62.5	62.0	61.5	61.5	60.0	54.0	52.0	52.5	53.0	53.0	53.0		52.0	50.5	51.0	
1983		64.0	64.5	63.5		60.5	57.0	54.0	53.0	53.0	53.0	52.5	52.5	52.5	52.5	52.5	
2357	59.5	60.0	60.0	59.5	59.0	58.0		53.5	53.5	54.0	54.0	54.5	54.0	54.5	53.5	54.0	
1257		60.0	60.5	59.0	59.0	57.0	56.5	53.5	54.0	53.0	53.0	53.0	53.0	53.0	54.0	53.0	
1916	61.0	60.5	60.5	59.5	59.5	58.5	53.5	51.0	51.0	52.0	51.5	51.0	51.0	51.0	51.0		51.0
2407		59.0	58.5	57.0	56.5	55.0	51.0	50.5	51.0	51.0	51.5	51.0	51.0		51.0		50.5
2030	63.0	62.0	62.0	61.5	60.5	59.5	56.5	55.5	55.0	55.5	54.0	54.5		54.5	54.5	54.5	
2629		66.5	66.0	64.5	64.0	60.0	57.5	56.5	57.0	57.5	56.5	57.5	56.5		57.0	56.0	

In this sample the mean bigonial widths (Fig. 5) increased in a similar manner, but the female remained proportional to the male until the age of 12, when the male values rose.

TABLE VIII. AGE CHANGES IN FACIAL WIDTH

	BIZYGOMATIC				BIGONIAL			
	MALE		FEMALE		MALE		FEMALE	
AGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE
3-0-0	101.15	12	98.25	11	70.95	10	68.89	11.5
3-6-0	102.88	12	101.07	9	72.50	10	70.57	12
4-0-0	104.54	10	102.06	11	73.29	10.5	71.89	11
4-6-0	105.73	10	103.54	8	74.75	11.5	73.16	11.5
5-0-0	107.17	10	103.89	13.5	76.35	10	74.00	12.5
6-0-0	109.07	10.5	105.57	10.5	77.71	12.5	75.23	13.5
7-0-0	110.46	10.5	107.78	14	79.60	11	77.28	13
8-0-0	112.21	10.5	109.35	11.5	81.64	11.5	79.32	13
9-0-0	113.17	10	110.70	12	83.17	11	80.64	13.5
10-0-0	115.38	9	112.64	13	84.57	11.5	82.14	14
11-0-0	116.78	9.5	114.92	14	85.82	14	83.65	15
12-0-0	118.14	9	117.25	12	87.03	13	85.26	14
13-0-0	119.96	12	117.66	10	88.53	10.5	85.29	10
14-0-0	122.22	9	119.53	13.5	92.13	10	87.10	12
15-0-0	124.70	11.5	120.58	13	93.25	11.5	87.70	13

Table IX indicates that the mean distance between the upper canines increases until the age of 7, decreases from then to the age of 10, increases rapidly until the age of 12 or 13, and thereafter increases slowly. The width at the age of 15 is considerably more than at the age of 3.

TABLE IX. AGE CHANGES IN INTERCANINE WIDTH

	UPPER				LOWER			
	MALE		FEMALE		MALE		FEMALE	
AGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE
3-0-0	30.90	3.5	30.60	5	30.15	6.5	29.71	6.5
3-6-0	32.34	4	31.75	5	30.84	6	29.92	6
4-0-0	32.29	8	32.28	5.5	30.83	5	29.92	6.5
4-6-0	33.08	7	32.33	6	30.87	5	29.79	6.5
5-0-0	34.25	6	33.42	7	30.82	5.5	29.89	6.5
6-0-0	34.53	7.5	33.76	6.5	30.50	7.5	29.0	7.5
7-0-0	35.14	7.5	33.85	6	29.82	7.5	28.0	6.5
8-0-0	35.03	8	33.21	6.5	28.75	8	26.85	8
9-0-0	34.10	6	32.92	9.5	28.28	4	27.10	8
10-0-0	33.88	4	33.50	8	29.57	7	28.39	7
11-0-0	34.67	7.5	35.80	10	29.71	5.5	29.84	6
12-0-0	35.57	11	37.33	8.5	30.64	6.5	30.16	5
13-0-0	37.32	11.5	37.58	7	30.75	4	30.16	5
14-0-0	38.54	10.5	38.03	8	31.27	3.5	30.17	4.5
15-0-0	38.62	11	38.29	6	31.04	4	30.29	5.5

The mean distance between the lower canines remains constant until the age of 6, after which it decreases until the age of 9. It then gradually increases until the fifteenth year, when it slightly exceeds that at the third year. The decrease prior to eruption occurs at an earlier age and is more pronounced than in the upper canines. Individuals occasionally exhibit larger measurements at the age of 3 than at the age of 15 (Cases 2035 and 2507). In some cases the 6-9 decrease is more pronounced than in the mean, but all cases showed some decrease prior to eruption.

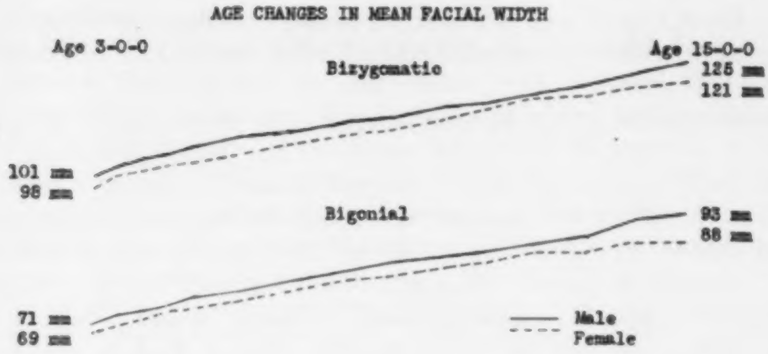


Fig. 5.

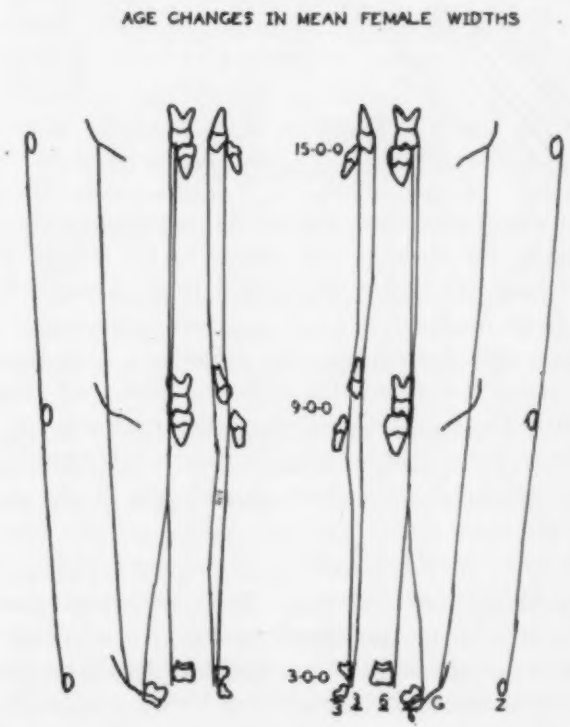


Fig. 6.—$\underline{3}$, Upper cuspid; $\overline{3}$, lower cuspid; $\underline{6}$, upper first molar; $\overline{6}$, lower first molar; *G*, gonion; *Z*, zygoma.

Table X indicates that the mean distance between the upper first molars increases fairly rapidly until eruption, after which it slows perceptibly.

The distance between the lower molars decreases until the teeth come into occlusion. After this it may increase, decrease, or remain stationary. In this sample the mean widths decreased slightly in the female and increased slightly in the male.

The mean pattern of the various facial widths in the female is summarized in Fig. 6.

TABLE X. AGE CHANGES IN FIRST MOLAR WIDTH

	UPPER				LOWER			
	MALE		FEMALE		MALE		FEMALE	
AGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE
3-0-0	51.15	8	49.32	10	63.30	10	62.07	7.5
3-6-0	51.69	8	50.07	9.5	63.07	9.5	61.85	7.5
4-0-0	52.08	8.5	50.71	9.5	62.08	10.5	60.85	7.5
4-6-0	52.57	7	51.12	7.5	61.25	10.5	60.12	7.5
5-0-0	52.64	7.5	51.28	7.5	60.60	11.5	58.78	5.5
6-0-0	53.14	7	52.07	7.5	57.35	13	56.07	7.5
7-0-0	54.39	8	53.32	6.5	55.75	11.5	54.03	6.5
8-0-0	55.46	8	53.96	6.5	54.85	8	53.64	6
9-0-0	55.67	8	54.28	6	54.78	8	53.78	6.5
10-0-0	56.11	8	54.75	5.5	54.92	6.5	53.53	5
11-0-0	56.17	10	55.15	7	54.89	7.5	53.57	6.5
12-0-0	56.53	10	55.25	7	55.28	7.5	53.29	5.5
13-0-0	56.75	8.5	55.20	6	55.14	9	53.08	3.5
14-0-0	57.59	7	55.25	7	55.86	8	53.07	6.5
15-0-0	56.95	9.5	55.79	6.5	55.16	10	53.25	5

IV. DISCUSSION

To the best of our knowledge this study represents the first attempt to examine quantitatively the changes that occur in the width dimensions of the dental arches throughout the entire eruption period. A number of investigators have published findings made directly on the teeth subsequent to their appearance in the mouth, and Broadbent has employed animated cinemagraphic methods based on serial x-rays to illustrate the paths of eruption of various teeth. Until the introduction of the Wylie compensator it has been impossible to measure accurately from frontal cephalometric roentgenograms, and hence the behavior of the teeth prior to their appearance in the mouth has been a matter of speculation.

Such measurements as bizygomatic and bigonial widths have been made by a number of investigators. Some of these have been conducted on skull collections and have resulted in the establishment of a series of norms representing the various stages of growth. Although the direct measurement of bones is the most accurate method at the disposal of the investigator, a cross-sectional method can yield only mean values and the peculiarities of individual patterns are completely missed.

Direct measurement of the living head during the growth period has the advantage of permitting the study of the individual and hence reveals any peculiarities and variations. But such direct measurement has the disadvantage of the error introduced by measuring through the overlying soft tissues. Serial

roentgenology eliminates the disadvantages of both methods provided satisfactory correction is made of the measurements taken in this manner. In addition to this, it is the only method that permits the scrutiny of the teeth prior to their appearance in the mouth.

Tables XI to XIV compare the results of this study with those obtained by others. Because the material for each study was obtained differently, they should be considered separately. West (1894) obtained his data from a study of 1,500 boys and 1,300 girls of the following races: 66 per cent American, 20 per cent Irish, 7 per cent English, 6 per cent other European. These he divided into age categories and arrived at a mean for each age. Goldstein (1936) took measurements of 500 Jewish boys biennially and stated his results as a series of means. Smyth and Young (1932) took a sample of 100 children aged 2 to 5 from a welfare clinic in London. They presented all types of occlusion and the subjects were about equally divided as to age and sex. Another sample consisted of 1,200 children with normal occlusion attending London County Council schools. They were about equally divided between relatively good and poor schools. The ages of these individuals ranged from 8 to 14, and they were of both sexes. Again the results were stated in terms of a mean for each age. Fleming (1933) measured a group of mixed Welsh and English children. There were 2,219 boys and 2,073 girls studied with a total of 6,395 observations on the boys and 6,221 observations on the girls. Although this was, in part, a serial study, the results were given in a group of means. Hellman (1932) reported on serial measurements of patients in his orthodontic practice; 526 were males and 670 were females. His results were stated in terms of dental age and were then tabulated in "average chronologic age" categories. Again the results were stated in terms of averages for the various stages. Davenport took serial measurements of 10 normal children aged 3 to 6 from a children's home, 100 boys and 50 girls aged 5 to 15 from a Brooklyn orphan asylum, and 250 boys and girls aged 5 to 20 from a feeble-minded home. This study was more truly of a longitudinal nature than those previously mentioned, and Davenport compared the behavior of the individuals against that of the mean and against other individuals.

A scrutiny of Tables XI and XII, which compare the values published by others with those resulting from this study, reveals that the corrected frontal x-rays consistently yield lower values. Davenport stated that he believed a correction of 10 mm. was proper for bigonial width taken on the living. When this correction was made, Davenport's values and those of Smyth and Young corresponded closely to those of the prsent study. Similarly corrected values fell midway between those of Fleming and Hellman.

A discrepancy was noted between our curve and that of Davenport prior to the 6-year level. The reason for this difference may well lie in the fact that Davenport's principal sample started at 5 years. To include the period before this he selected 10 normal children from a children's home and took serial measurements of them from the third to the sixth year. On such a small sample there could well be a significant difference between the mean of the two groups. Indeed, one individual in our group (Case 2462), female, yielded values corresponding closely to his.

TABLE XI. AGE CHANGES IN BIGONIAL WIDTH

AGE	MALE						FEMALE				
	SMYTH AND YOUNG	GOLDSTEIN	FLEMING	HELLMAN	DAVENPORT	WOODS	SMYTH AND YOUNG	FLEMING	HELLMAN	DAVENPORT	WOODS
2/6/0	84.27				85		84.24			83	
3/0/0					85	70.95				84	68.89
3/6/0	86.68					72.50	85.03				70.54
4/0/0					86	73.29				84	71.89
4/6/0	88.28					74.75	86.12				73.16
5/0/0		81.9			86	76.35				85	74.00
5/6/0				83.06					82.05		
6/0/0			97.38		87	77.71		96.18		86	75.23
6/6/0											
7/0/0		84.6	97.91		87	79.60		94.72		87	77.28
7/6/0				85.31					84.13		
8/0/0			99.0		89	81.64		94.82		89	79.32
8/6/0	96.18						94.02				
9/0/0		89.0	100.72	88.10	90	83.17		96.32	86.74	89	80.64
9/6/0	97.91						94.89				
10/0/0			100.07		93	84.57		98.28		91	82.14
10/6/0	97.80						95.92				
11/0/0		93.2	101.48	90.70	95	85.82		99.07	89.87	93	83.65
11/6/0	99.30						96.63				
12/0/0			102.69		96	87.03		100.66		94	85.26
12/6/0	100.54			93.53			98.24		90.66		
13/0/0		95.9	104.67		97	88.53		101.93		94	85.29
13/6/0	100.17						99.35				
14/0/0			106.50		98	92.13		105.04		95	87.10
14/6/0											
15/0/0		98.1	108.29	97.08	99	93.25		105.43	94.09	95	87.70

TABLE XII. AGE CHANGES IN BIZYGOMATIC WIDTH

AGE	MALE							FEMALE					
	WEST	SMYTH AND YOUNG	GOLD-STEIN	FLEMING	HELLMAN	DAVEN-PORT	WOODS	WEST	SMYTH AND YOUNG	FLEMING	HELLMAN	DAVEN-PORT	WOODS
2/6/0		111.35				112			109.06			108	
3/0/0			107.3			113	101.15					109	98.25
3/6/0		110.32					102.88		110.94				101.07
4/0/0						114	104.54					110	102.06
4/6/0		115.06					105.73		110.35				103.54
5/0/0	114		115.8	111.00		115	107.17	112		109.20		111	103.89
5/6/0					117.12						113.26		
6/0/0	114			113.38		116	109.07	114		113.00		112	105.57
6/6/0													
7/0/0	117		121.0	113.83		117	110.46	114		112.01		113	107.78
7/6/0					119.77						116.80		
8/0/0	116			116.19		118	112.21	115		113.04		115	109.35
8/6/0		119.99							117.68				
9/0/0	120		125.9	117.44	121.31	119	113.17	117		113.68	119.29	116	110.70
9/6/0		121.44							119.99				
10/0/0	120			117.42		120	115.38	118		114.92		118	112.64
10/6/0		122.70							120.06				
11/0/0	121		129.5	118.51	123.44	121	116.78	120		116.90	123.25	120	114.92
11/6/0		123.71							121.73				
12/0/0	122			120.14		123	118.14	122		119.12		123	117.25
12/6/0		125.55			126.47				123.55		125.44		
13/0/0	124		133.0	122.88		125	119.96	123		120.85		124	117.66
13/6/0		125.73							125.57				
14/0/0	126			125.46		127	122.22	125		122.85		124	119.53
14/6/0													
15/0/0	129		135.6	127.22	130.36	128	124.7	126		124.76	128.06	125	120.58

TABLE XIII. AGE CHANGES IN UPPER MOLAR WIDTH

AGE	MALE				FEMALE			UNKNOWN		
	SMYTH AND YOUNG	COHEN	WALLACE	WOODS	SMYTH AND YOUNG	COHEN	WOODS	GOLDSTEIN	ZSIGMONDY	FRANKE
2/6/0										
3/0/0				51.15			49.32			38.3
3/6/0				51.69			50.07			
4/0/0				52.08			50.71	41.7		39.9
4/6/0				52.58			51.12			
5/0/0				52.64			51.28	43.8		39.9
5/6/0										
6/0/0				53.14			52.07	43.4		41.6
6/6/0		39.2				40.1				
7/0/0			33.4	54.39			53.32	43.6		41.6
7/6/0		39.6	33.0			40.0				
8/0/0			34.0	55.46			53.96	43.9	34.5	43.4
8/6/0	55.53	40.1			53.61	40.1			34.5	
9/0/0			33.8	55.67			54.28	44.0		43.4
9/6/0	56.00	40.3			53.76	40.7				
10/0/0				56.11			54.75	44.4		44.2
10/6/0	55.98	40.5			54.63	41.0				
11/0/0			33.5	56.17			55.15	45.0	34.9	44.2
11/6/0	56.79	40.8			55.01	41.3				
12/0/0			34.0	56.53			55.25		35.2	44.8
12/6/0	57.35	41.0			55.47	40.9				
13/0/0				56.75			55.20		35.2	44.8
13/6/0	56.66	40.7			55.99	41.3				
14/0/0				57.59			55.25			44.4
14/6/0			33.9							
15/0/0				56.95			55.79			44.4

TABLE XIV. AGE CHANGES IN LOWER MOLAR WIDTH

AGE	MALE				FEMALE			UNKNOWN		
	SMYTH AND YOUNG	COHEN	WALLACE	WOODS	SMYTH AND YOUNG	COHEN	WOODS	GOLDSTEIN	ZSIGMONDY	FRANKE
2/6/0										
3/0/0				63.30			62.07			42.2
3/6/0				63.07			61.85			
4/0/0				62.08			60.85			42.2
4/6/0				61.25			60.12			
5/0/0				60.60			58.78	42.0		43.5
5/6/0										
6/0/0				57.35			56.07	41.9		43.5
6/6/0		35.0				36.1				
7/0/0			32.6	55.75			54.03	42.3		43.9
7/6/0		34.5	32.7			36.5				
8/0/0			32.0	54.85			53.64	42.8	32.0	43.9
8/6/0	53.58	34.8			52.09	36.8			32.0	
9/0/0			32.3	54.78			53.78	43.15	32.0	44.5
9/6/0	53.88	34.9			52.05	37.2				
10/0/0				54.92			53.53	43.6	32.0	44.5
10/6/0	53.75	35.1			52.71	37.3				
11/0/0			31.2	54.89			54.89	43.2	32.0	45.2
11/6/0	54.77	35.2			52.91	37.4				
12/0/0			31.2	55.28			53.29			45.2
12/6/0	54.97	35.2	31.3		53.36	36.9				
13/0/0				55.14			53.08		32.0	45.4
13/6/0	54.42	35.0			53.66	37.0				
14/0/0				55.86			53.07			45.4
14/6/0			31.1							
15/0/0				55.16			53.25			45.2

The differences in the values obtained for bizygomatic measurements in this study and those obtained by others are similar in kind to those of bigonial measurements. However, less correction (6 mm.) is needed in this area because of the difference in thickness of the soft tissue covering. With this amount of correction the curve derived from the x-ray measurements agrees closely with all other studies save that of Goldstein which is high in all of its values. No explanation of this difference is available except that he had a relatively pure sample upon which to work.

Tables XIII and XIV compare the width of the denture at the first permanent molar published by others with that resulting from this study. Franke (1921) used 1,200 skulls and 150 casts of abnormal jaws. He measured the distance on the bone between the mid-points of the arch at the middle of the first molar sockets. He divided these into age categories and arrived at a mean for each age. Smyth and Young (1932) used the same material and handled it in the same manner that was described with the facial widths. Zsigmondy (1890) took serial measurements of one individual. Wallace (1927) presented serial measurements of his son. Goldstein (1935) took casts of 546 sets of dentures from 300 middle class children with normal and abnormal dentures. The number of cases that figured in his mean ranged from 1 to 59 with the ages of 6, 7, 8, and 9 having more than 36 cases each. Cohen (1940) made a longitudinal study of 28 children, 15 boys and 13 girls, from 3½ to 13½ years of age. The individuals selected were fairly representative of the population of Minneapolis. He arrived at a mean width at each age, and compared an individual with this mean.

The upper first molar widths (Table XIII) increase after the eruption of the teeth by 1 or 2 mm. This is reported constantly by all authors, although the actual size varies considerably because of the selection of different points on the teeth for measurement.

The pattern of lower first molar widths (Table XIV) after eruption is not as uniform as the upper. Some men have shown an increase, others a decrease, and others have found no change in width after eruption. In this study mean measurements show about 0.5 mm. increase in width in males and a similar amount of decrease in females after the age of 8. Smyth and Young showed a mean increase of about 1 mm. in both sexes, although a graph of one case was presented in which the width decreased. Goldstein's mean also showed 0.5 mm. increase. Zsigmondy's one case showed no change in width. Wallace's one case showed almost a millimeter decrease in width after the age of 8.

V. CONCLUSIONS

1. It is possible, with the aid of the Wylie compensator, to make accurate measurements from frontal cephalometric roentgenograms, provided the landmark to be measured can be located in both the frontal and lateral films. Measurements thus obtained compare favorably with the same measurements taken directly from living individuals or from plaster casts of the mouth.
2. Bizygomatic width increases steadily from the ages of 3 to 15.
3. Bigonial width increases steadily from the ages of 3 to 15.

4. The upper intercanine width increases gradually during the growth period except for a decrease between the ages of 7 and 12.

5. The lower intercanine width remains about the same during the ages of 3 to 15, except for a decrease in width between the ages of 6 and 11.

6. The width between upper first molars increases until these teeth come into occlusion and then continues to increase at a much slower rate.

7. The width between lower first molars decreases gradually until these teeth come into occlusion. After this, width increases remains constant, or decreases, in different cases.

8. The principal sex difference found in this study was one of absolute size, the female being slightly smaller than the male in all dimensions.

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DENTAL CEMENT: A STUDY OF ITS PROPERTY OF ADHESION

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INTRODUCTION

Dental cement is of major importance in the practice of orthodontics. It is used more extensively by the orthodontist than by his colleagues, and he relies more on its performance than they. He is forced to place thin, narrow, mechanically weak bands on teeth without altering the shape of the teeth. This procedure is a handicap in obtaining retention of these bands. No matter how skillfully an orthodontic band may be shaped, it will not keep its retention on a tooth throughout functional use without the aid of cement.

This statement is not intended to minimize the importance of proper band construction. Cements being what they are, band construction is a far greater factor than cement in band retention. Besides the role cement plays in attaching bands to teeth, the orthodontist calls upon it to protect the tooth under the band from caries.

For these reasons, the chemical and physical properties of dental cement are of prime interest in the practice of orthodontics. These properties, solubility, volumetric changes, crushing strength, adhesion, translucency, and setting time, have been extensively studied, some more than others. This report is concerned only with the property of adhesion.

REVIEW OF THE LITERATURE

A search of the literature reveals that there has been but little investigation of the adhesive property of dental cement. This is rather surprising, since adhesive tests are quite simple to perform.

In a package library of thirty-two articles concerned with the properties of dental cements, compiled by the Library Bureau of the American Dental Association, only three articles mentioned adhesion.[1, 2, 3] In only one of these articles was there a report made of an investigation of the adhesiveness of a dental cement. Textbooks mention the subject in discussions of ideal properties of materials for dental use. But nowhere was the writer able to find a report of the numerical values of dental cement adhesion.

Paffenbarger et al.[3] reported some experiments on adhesion and an excellent discussion on the subject. Since their comments summarize a carefully considered opinion concerning adhesion, the following material from their report is given:

"Several manufacturers claim their zinc phosphate cements are adhesive and many practitioners believe this to be true. Cements of the silicious type are said to be non-adhesive. This distinction is probably based upon the fact that the zinc phosphate cements are sticky or 'tacky' in the soft unset state and

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easily wet surfaces to which they are applied, while the silicious type do not. This is probably a matter of surface tension as the silicious cements have a greater tendency to become spheroidal than the zinc phosphate cements. When the zinc phosphate cements harden, they no longer adhere to gold, steel, ivory or human tooth tissue.

"Some tests for measuring adhesiveness of dental cements have been reported. Practically all of these tests measure the load necessary to dislodge a plug or crown from a block or die. It seems that what was actually being measured was not the load required to overcome the adhesive force of the cement, but the shearing or crushing strength of the cement particles. This explains why appliances are sometimes difficult to remove. The cement simply flows into all the minute irregularities and locks the appliance in place. When the appliance is removed, the cement is crushed."

Skinner[6] reported that the thickness of the dental cement film is important; that tests have shown adhesion is greater when the film is thin than when it is thick.

Castello et al.[1] found that cement adhered to tooth surfaces covered with collodion to the same extent that it adhered to uncovered enamel. This finding was the basis of a suggestion that a protective film might be painted on teeth before applying cement, the film serving to eliminate the harmful action of cement acid on enamel. They also suggested that lowering the surface tension of cement mixtures might increase its adhesion.

Rousch[2] stated that cements set with crystals extending into microscopic scratches in cavity wall surfaces and surfaces of inlays and crowns, and these act as a lock, causing adhesion. He pointed out that glazed surfaces are not ideal for cementation.

Thus we find that opinions in dental literature agree upon the ability of zinc phosphate cements, but not silicates, to create a form of mechanical adhesion. These opinions also agree that there is no inherent ability of cement to adhere to tooth surfaces by means of pure adhesive force, the force of attraction existing between the molecules of an adhesive and an adherent.

THEORIES OF ADHESION

An adhesive is generally considered as any material which will adhere to the surface of another material. It is usually employed to join together two or more structures to form one structure. An ideal adhesive would join together materials with a bond that would equal or exceed the physical strength of the materials themselves. This condition has been obtained in the development of some of the paper and wood adhesives. It is quite common now to observe failures in wooden assemblies in which the bond joints have held while the wood itself has broken. This ideal has not yet been attained extensively in the field of materials possessing hardness and impenetrability, such as metals and ceramics.

There are many factors to be considered in studying the phenomena of adhesion. They are obviously chemical and physical in nature and concerned with surfaces; the surfaces of the structures to be joined and the surface of the

bonding material. These factors have been broadly classified by Browne and Brouse as mechanical and specific.

The mechanical factors are concerned with the action of an adhesive, while fluid, in entering minute openings in the surface of a material. After solidification takes place, the adhesive becomes mechanically locked by means of these protrusions in tight contact with the material. This is the type of bond which is a major factor in paper and wooden assemblies.

Observation of satisfactory bonding of materials with smooth, impenetrable surfaces led to the formation of the theory of specific adhesion. The factors in specific adhesion are concerned with the complexities of surface chemistry and surface physics. DeBruyne's investigations of the attractive forces between molecules and atoms led to the theory of the part of polarity in adhesion, particularly specific adhesion. Secondary forces exist between molecules and atoms which may be of two distinct kinds, polar and nonpolar. These forces are electrical in nature, although the atoms and molecules themselves are electrically neutral. Experience shows that strong joints cannot be made with polar materials and nonpolar adhesives, nor nonpolar materials with polar adhesives.

Film thickness is often a critical matter in the success or failure of a bond. Theoretically the thickness of an adhesive should make no difference in bond strength. The cohesion between molecules or crystals in a film one-eighth inch thick should be the same as in a film of molecular dimensions. However, structural faults are always present in adhesive materials. So the thinner the film, the fewer are the faults likely to be present.

The important factors in adhesion, then, are the surface characteristics of the materials being bonded: polarity, porosity, smoothness, penetrability, cleanliness; and the characteristics of the adhesive: (1) surface tension, (2) volumetric changes during the hardening process, (3) tensile, shear, and compressive strengths, (4) elasticity, (5) creep rate, (6) polarity, (7) voids and structural defects, (8) film thickness.

METHODS AND MATERIALS

A method of testing only the tensile strength of a comparatively flat surface bond between enamel and gold was chosen. This approach would seem to give a clear indication of the amount of specific adhesion of dental cement to tooth enamel and gold. It eliminates the influence of mechanical retention obtained when a closely fitting plug-in-a-hole device or a clasp type of appliance is used. It also eliminates the necessity for overcoming the crushing strength of the cement. This important consideration was pointed out earlier in the Paffenbarger report.

Six lower molars were invested in stone blocks with their buccal surfaces exposed. Plates 1/32 inch thick and 12/32 inch by 7/32 inch were cast in hard gold alloy to fit onto these surfaces. A hook of 19-gauge Ticonium wire was soldered to the center of each plate. The cementing surfaces of the plates were roughened with a stone. A wooden testing apparatus (Fig. 1), was constructed so that tensile force from a bolt and screw was applied through a spring scale.

The scale was one of the better quality Hansen scales, permitting adjustment of the pointer. It was calibrated in pounds from zero to fifty.

Before each cementation the teeth were thoroughly cleaned mechanically. No chemicals were used for this purpose. Cement was removed by chipping and followed by pumicing and flushing with water. The plates were cleaned for each test with hydrochloric acid and rinsed with water.

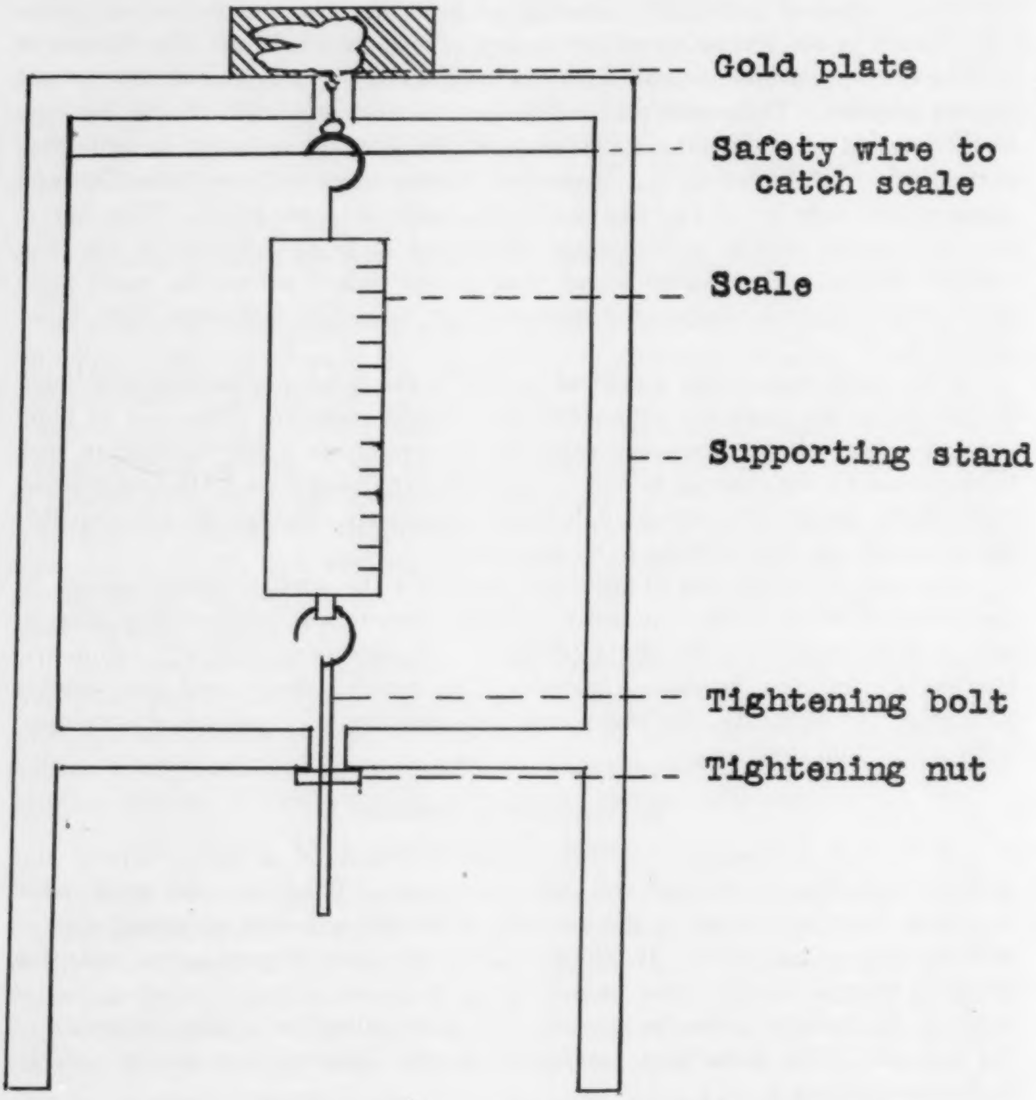

Fig. 1.—Apparatus used for testing tensile strength of cement bond.

A medium consistency of cement was chosen because it is most commonly used. The cement was applied only to the plate, and it was carefully pushed into position with firm pressure until seated. Pressure was not sustained. Usually three plates were cemented with each mixture. All in all, the method

and materials closely approximate those used in clinical practice. It is not possible, of course, to dry teeth in the mouth as thoroughly as in these tests.

The cements were from a supply-house stock. They were chosen because they are among those which are widely used.

DATA

In the tables, the Roman numeral at the top of the column indicates the brand of cement used.* Each capital letter represents a single mixture of cement. The readings in pounds at the time of plate separation are given alongside. Just below each series is the arithmetical average of the readings in the series. Just below the average is listed the average value converted into psi (pounds per square inch). Psi was obtained by multiplying the average value of the readings by 12.2:

$$12/32'' \times 7/32'' = 84/1024 \text{ sq. in.} = 0.082 \text{ sq. in.} \qquad 0.082 \text{ sq. in.} \times 12.2 = 1 \text{ sq. in.}$$

Although not listed in the tables, observations were made in each case concerning the film thickness and whether the cement stuck to the enamel or the tooth. Report of these observations will be given in the discussion.

TABLE I

	I		II		III		IV		V
A.	10.5	A.	5.5	A.	7.0	A.	9.0	A.	5.5
	7.5		10.5		6.0		9.0		4.0
	12.5		11.5		5.5		11.5		5.5
B.	9.0	B.	10.0	B.	6.5	B.	8.5	B.	7.0
	10.0		5.0		5.0		4.0		7.0
	12.5		9.5		8.5		12.0		5.0
C.	11.0	C.	7.0	C.	3.5	C.	11.0	C.	7.5
	10.0		9.0		6.0		4.0		9.5
	13.5		8.5		10.0		8.0		5.0
	10.7		8.5		6.4		8.5		6.2
	130.5 psi		103.7 psi		80.5 psi		103.7 psi		76.6 psi

	VI		VII		VIII		IX
A.	10.0	A.	8.0	A.	7.0	A.	6.5
	8.5		7.5		7.5		6.0
	8.0		13.0		9.0		7.5
B.	5.0	B.	6.5	B.	8.0	B.	5.5
	5.0		9.0		6.5		8.0
	9.5		7.0		7.0		6.0
C.	7.0		8.5		7.5	C.	5.5
	9.5		103.7 psi		91.5 psi		6.0
	10.5						5.5
	8.1						6.3
	98.8 psi						76.9 psi

Specimens were placed in water after cement had set for ten minutes. Tests were made eighteen hours later, while specimens were still wet.

*I. Ames Crown & Bridge #6
II. Di-Cem #2
III. S. S. White #12
IV. Ames Black Copper
V. Tenacin
VI. Fleck's pearl gray
VII. S. S. White Silver Cement
VIII. Caulk Pro-Tem
IX. S. S. White Filling Porcelain

TABLE II

	I		IV
A.	5.0	A.	No adhesion
	8.0		No adhesion
	7.5		No adhesion
B.	7.0	B.	No adhesion
	5.0		No adhesion
	6.0		No adhesion
C.	2.0		
	4.0		
	7.0		
	5.7		
	69.6 psi		

Specimens in this series were allowed to remain dry for twenty-four hours and then tested while dry.

TABLE III

	I		IV
A.	5.5	A.	3.0
	7.0		4.0
	6.0		3.5
B.	8.0	B.	2.0
	6.5		4.0
	9.5		7.0
	7.1		3.9
	86.6 psi		48.8 psi

Specimens were placed in water after ten minutes, left in water for eighteen hours, removed, and allowed to dry out for two hours before testing.

TABLE IV

	I		IX
A.	13.5	A.	5.5
	11.0		4.5
	13.0		5.0
B.	10.0	B.	4.0
	12.0		3.5
	9.0		5.5
C.	7.0		4.7
	10.0		56.1 psi
	12.5		
D.	9.0		
	8.5		
	10.0		
	10.5		
	128.1 psi		

Specimens were placed in water after cement had set for only one minute. Tests were made eighteen hours later, while specimens were wet.

TABLE V

	I
A.	4.5
	6.0
	4.0
B.	5.0
	3.5
	3.0
	4.3
	52.5 psi

In this series, a thin mix of cement was used. The cement was allowed to harden for forty-five minutes and the specimens were then placed in water. Tests were made eighteen hours later.

TABLE VI

I
A. No adhesion
7.0
No adhesion
B. No adhesion
3.0
No adhesion

Specimens were placed in water for five minutes, removed, and excess water shaken off. No attempt was made to dry them before cementation. After cement had set for three minutes, the specimens were placed in water for eighteen hours and then tested.

TABLE VII

I
A. 10.5
B. No adhesion
C. No adhesion
D. 3.0
E. No adhesion
F. No adhesion

A "C" clamp was applied to the specimen immediately after seating the plate, and strong pressure applied. The "C" clamp was allowed to remain on the specimen for eighteen hours. They were placed in water after cement had hardened for ten minutes.

TABLE VIII

	I
A.	6.5
	6.0
	6.0
B.	4.0
	5.0
	4.5
	5.3
	64.7 psi

The cementing surfaces of the plates were polished smooth. Cement hardened for ten minutes; specimens were then placed in water for eighteen hours and tested wet.

TABLE IX

	I
A.	14.0
	12.0
	12.5
	14.0
	13.1
	169.8 psi

Eight holes, 0.025 inch in diameter, were drilled through each of the four plates in order to obtain greater retention. Cement hardened for ten minutes and specimens were placed in water for eighteen hours and then tested.

TABLE X

	Duco Household Cement
A.	19.0
	17.0
	20.0
	19.0
	231.8 psi

The cement was allowed to set for twenty-four hours in air and then tested.

DISCUSSION

In the writer's opinion, the most interesting observation during these tests was that in each case the cement adhered to the enamel and not to the metal

plate. In only 5 cases out of the 150 reported did a noticeable amount of cement adhere to the plate. Even in these 5 cases, most of the cement adhered to the enamel. In the tests where retention holes were used in the plates (Table IX), the cement in and around the holes remained on the plate. The greater amount stuck to the tooth. These tests, then, indicate that cement has a certain amount of specific adhesion to enamel, and a much lesser amount to gold. Also, the values obtained illustrate the amount of adhesive force between the cement and the plate, rather than between the cement and the tooth.

Variations in the adhesiveness of different brands of cement are illustrated in Table I. The most surprising result to the writer was that black copper did not show up better than the zinc phosphates. Black copper has a reputation of possessing superior qualities of adhesion.[4, 5] The writer has heard several orthodontists speak of using black copper for cementing onlays.

It would be interesting to know just why there is apparently so much variation in the adhesiveness of different cements which are basically similar in chemical composition. It may be that the small variation in the chemical composition of the various cements is the reason for the differences in adhesiveness. Again, it may be a variation in surface tension. It is not at all unlikely that some of these cements microscopically etch the surface of enamel and create greater adhesion in this manner.

Tables II, III, IV, and VI show the variations in adhesion due to the absence or presence of moisture, before and after cementation. Cementations performed when the specimens were moist did not possess any adhesion (Table VI). Complete dryness lowered the adhesion of the zinc phosphate and it completely disappeared from the black copper (Table II).

Table III shows how drying out of wet cement lowers its bond strength. If this test is valid, it would indicate that moisture is essential to maintain the adhesive power of the cement. This condition is not true in the case of adhesives generally. With most materials, absolute dryness after the material sets is an ideal condition. This moisture is mechanically retained, and in a chemical sense the properties of the material are not affected. Nor is the physical strength altered.

But the presence of mechanical moisture does have an effect on the physical characteristics of some materials. The flexibility of Portland cement is lowered by the loss of mechanical water. Plaster of Paris, completely dry, reacts differently than plaster which contains some moisture. It is quite likely that moisture creates a type of colloidal system which alters some of the properties. This alteration goes beyond volumetric changes, expansion, and contraction, which may occur.

Comparing Tables IV and I, we see the strength of zinc phosphate was not lowered by putting it in water after setting only one minute, instead of ten minutes. At this time it was still quite soft. The silicate, however, lost about one-third of its adhesiveness. Table V indicates that excessively thin mixtures of cement have only half the adhesiveness of medium mixes.

The results of the tests in Table VII are considered unreliable. Experience with adhesives commonly used would indicate that clamping would greatly

increase the strength of the bond. It must be borne in mind, however, that most adhesives are organic and made up of long chain molecules, while dental cements are inorganic and crystalline. Perhaps pressures of high magnitude weaken rather than strengthen the bond in adhesives of this type. At any rate, the influence of pressure during the hardening stage deserves further investigation.

Adhesion of the cement to the metal plate is greatly increased when the surface of the plate is roughened or some means of mechanical retention provided (Tables VIII and IX).

In order to obtain a comparison between the numerical values of dental cement and another type of cement, the tests shown in Table X were made. Duco cement is not a good adhesive. Yet the bond strength surpassed that of dental cement. Of course, it is not a waterproof cement and would completely lose its adhesion if placed in water.

The tables show considerable variation in values even in the cases where the same mix was used for several specimens. Observation of the film thickness in each case rules out the influence of improper seating of the plate. In all cases the cement film was comparatively thin. The variations are probably due to the presence of surface films and microscopic faults in the cement, such as gas bubbles, areas of excess acid or powder which were not completely mixed, or foreign particles. Such areas appear in every mixture. It is quite impossible to produce a mixture which is homogeneous throughout.

In these tests no attempt was made to study adhesiveness after cement had remained in water for a long time. Undoubtedly the results would be different if the cement were subjected to water submergence for several months. Cement subjected to the disintegrating forces in the oral cavity for a period of time would also show a marked change in its physical properties.

SUMMARY AND CONCLUSIONS

If the data collected in the course of this investigation are valid, dental cements must definitely be considered as possessing a certain amount of specific adhesion to enamel. The amount of adhesion varies in different brands of cement, indicating that small variations in chemical composition affect the property of adhesion. The adhesive force varies considerably with the method of application of the cementing material and the conditions at the time of application. The presence of moisture or of dryness at the time of application, and also after the cement has hardened, has a pronounced effect on adhesive strength.

Throughout these tests, the metal plate separated from the cement film before the cement film separated from the tooth. Because of this, no values could be obtained concerning the specific adhesion of cement to enamel.

The writer is not attempting to convince the reader that dental cement is a satisfactory adhesive. It is not. Nor is he wishing to infer satisfactory adhesion to enamel during these tests. The cement chipped away too easily. Still, under certain conditions, cement does display a tenacity to enamel that is perplexing. Who has not had the experience of encountering patches of

cement on smooth surfaces which were extremely difficult to remove? This occasional adhesiveness of great magnitude is challenging. It must be due to regions of optimal chemical composition in the cement mixture and to optimal pressure application on that area, during a time when conditions for application are favorable. When we learn why these certain patches of cement adhere so strongly, we may learn to apply cement in such a manner that it will be a satisfactory adhesive.

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ROBESON BLDG.

Editorial

The George Wellington Grieve Memorial Lecture

As FAR back as memory can go, there has always been a close bond of friendship and cooperation between the orthodontists of Canada and America. When a small band of American dentists limited their practices to orthodontics in 1901, it remained for a Canadian leader to follow two years later.

Dr. Arthur Roberts, of Toronto, in 1903, was the first dentist to limit his practice to orthodontics in Canada. The next was Dr. Guy Hume, who became associated with Dr. Roberts in 1904, and who later succeeded him. Dr. Hume was for some time the only orthodontist in Canada. Dr. Hume became a graduate of the Angle School in 1906, and after loyal active years of service to the American Association of Orthodontists became its president in 1914. He also gained international fame for the fine maxillofacial splints that he made for Canadian soldiers of World War I.

In 1907 Drs. George W. Grieve, of Toronto, and J. A. C. Hoggan, of Hamilton, took the Angle Course and specialized in their respective cities. Dr. Grieve was a particularly active member of the American Association of Orthodontists and was the fourth recipient of the Albert H. Ketcham Award in 1940. Dr. A. C. Corrigan was also a member of the 1907 Angle class, but on his return to Toronto, he continued the practice of general dentistry until active service in World War I, following which he succeeded Dr. Hume as Professor of Orthodontics in the Faculty of Dentistry, University of Toronto.

Also in 1907 Drs. Fulton Risdon, W. J. Lea, of Toronto, and B. E. Brownlee, of Winnipeg, took a course of instruction under Dr. B. E. Lischer and his associate Dr. Lukens at St. Louis, Missouri. Dr. Lea later went to Vancouver. For a short time Dr. Risdon practiced orthodontics in Toronto, but continued with his medical studies and became an outstanding maxillofacial and plastic surgeon.

In Winnipeg, orthodontics has its inception in 1909 when the late Dr. Manley Bowles limited his practice after completing the Angle Course the previous year. In 1912 Dr. B. E. Brownlee also started to specialize in orthodontics.

A list of other Canadian orthodontists who have gained prominence includes: William W. Woodbury, of Halifax; A. W. McClelland, Gerald Franklin, M. L. Donigan, and Paul Geoffrion, of Montreal; Dr. Geoffrion is at present Vice-President of the Northeastern Society of Orthodontists; Sydney W. Bradley and the late Charles H. Juvet, of Ottawa; G. Vernon Fisk, S. Stuart Crouch, Harvey G. Bean, and the late C. Angus Kennedy, all of Toronto; and Dr. Reyburn R. MacIntyre, of Calgary.

Orthodontic practice is developing and expanding throughout Canada in a manner that already forecasts its standing high among the professions and in public esteem. Out of forty-six orthodontists at present in exclusive practice in Canada, twenty-four are members of the American Association of Orthodontists, whilst eleven living and two deceased members are diplomates of the American Board of Orthodontists . . . a most creditable record.

Evidence of this development was manifest recently when the Canadian orthodontists requested the Board of Governors of the Canadian Dental Association to form an Orthodontic Section within the structure of the C. D. A. This request was granted.

As a memorial to the late Dr. G. W. Grieve, the Canadian orthodontists also recommended to the Board of Governors of the Canadian Dental Association that a lectureship in orthodontics be established to be known as *The George Wellington Grieve Memorial Lecture.* This recommendation received favorable consideration by the Board of Governors.

THE CONDITIONS GOVERNING THE LECTURE

1. A fund to be established by the Canadian Dental Association known as the Grieve Memorial Lectureship Fund is to be provided through voluntary contributions of the members and from any others who wish to contribute.

2. The total contributions of the fund will be invested by the Secretary-Treasurer of the Canadian Dental Association upon the authorization of the Executive Committee in a trust, the trustees of which will be officers named in *6.*

3. The income from the investment of the principal sum of the fund will be used to defray the traveling expenses of a lecturer.

4. The lecture is to be delivered on an annual basis if an individual is deemed worthy of the honor.

5. The basis for the selection of an individual to receive the invitation to prepare and present the lecture shall be meritorious service in the scientific, educational, or clinical aspects of orthodontics, or in any other closely allied field of activity.

6. For the purpose of selecting an individual to deliver the lecture a special committee will be set up composed of the Secretary of the Canadian Dental Association, and the Chairman and Secretary of the Orthodontic Section. The selection by this committee must be unanimous and their decision will be final.

7. The time of the lecture will ordinarily coincide with the annual meeting of the Canadian Dental Association.

The George Wellington Grieve Memorial Lecture will not only be valuable as a memorial to a great orthodontist, but it will also serve as an elevating influence, and as a stimulus to future accomplishments, both in Canada and elsewhere.

The sponsors of this memorial have a host of friends in America who wish them success in their worthy objective. What a fine gesture it would be if we Americans could be instrumental in assisting them in the accomplishment of this laudable purpose. If each of us, within our means, made a donation to this cause, it would be a source of great satisfaction to all concerned, and further strengthen the bonds of true friendship.

Members of the American Association of Orthodontists who wish to express their appreciation and accord may send individual contributions to Dr. Donald W. Gullett, Secretary, Canadian Dental Association, 211 Huron Street, Toronto 5, Ontario, Canada.

J. D. E.

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Bringing Orthodontics to the School Child: By G. E. M. Hallett, F.D.S.R.C.S. Eng., H.D.D. Edin., L.D.S. Liv., *Brit. D. J.* **83**: 201-207, April, 1950.

Smyth, during her survey of several thousands of London school children, had to reject 92 per cent when selecting her "normal" material. Salzmann, quoting from a survey made at the Guggenheim Clinic (1946) of 476 children aged 2-9½, states that 50 per cent had minor malocclusions, and 10 per cent had Angle Class II, or other severe malocclusions. Four hundred seventy-six hardly seems to be a sufficient number upon which to draw definite conclusions, and the very mixed character of the age groups would vitiate the results. Nevertheless, one feels that the figure of 10 per cent quoted for severe malocclusions must have been a minimal one, for many of the 2- and 3-year-olds must subsequently have come into the category. In a comprehensive survey of school children in widely separated areas, Mr. Ainsworth, investigating the incidence of dental disease in children for the M.R.C. in 1924, reported that anteroposterior malocclusions, unilateral or bilateral, were found in 23.2 per cent of all children examined. However, Mr. Ainsworth classified many cases as normal where anteroposterior discrepancies of molar relationship had occurred as a result of early loss of the deciduous molars, and excluded most of Bennett's Class I type of malocclusion. When this is taken into account, malocclusions present, needing treatment, must rise considerably above the figure of 23 per cent.

Other investigators have been Mr. Breakspear reporting on 200 unselected cases in 1943, Mrs. Michaelis reporting upon 233 cases in February, 1945, and Miss Sclare investigating malocclusions in the age groups (8 and 12) in a survey of 650 children.

Professor Humphreys and Mr. Leighton have published some interesting observations conducted upon 3,380 preschool children between 2 and 5. They found that about 25 per cent showed some degree of postnormality and 1 to 5 per cent had prenormality.

Esthetic appeal is probably the most powerful weapon in our propaganda armory. Indeed, parents can be embarrassingly grateful at having the child's twelve anterior teeth aligned, even though one is not a little mortified by a disappointing occlusal relationship of the molars. Premolar and molar malocclusion mean very little to the layman. Quite gross malocclusion can, in certain instances, be compatible with longevity of the teeth. Amongst a group of school children from an independent school at a social function recently, Hallet could not but be conscious of the number of Class II and other severe malocclusions present. Yet only a small number of those cases were receiving orthodontic treatment. The reason was not a question of income. Medical attention in other directions was not lacking, but apparently parental indifference; or parental cynicism, often justified, "I wore a brace when I was a girl but my teeth went back as soon as I left off"; or sheer inability to get skilled attention for lack of specialists; or, finally, a careful weighing up of

the advantages to be gained by treatment against the loss of school time occasioned by attendances at the dental surgeon's, and putting the school factor as the higher.

If we take 10 per cent of the school children as not only requiring orthodontic treatment but desiring it themselves, and limiting the age groups from 8 to 14, we get a figure of about 3 million children of whom 300,000 require active treatment. Our next difficulty is to compute the number of cases an orthodontist may reasonably be expected to treat. Here again, there is a great divergence of opinion. A well-known American orthodontist, whose advice I sought upon this point, told me that he could have up to 100 cases upon his treatment lists at any one time. On such a reckoning, we should need for the treatment of our children something like 3,500 orthodontists or 25 per cent of the total register. Of course, that this applies to American orthodontic private practice in its most exclusive and expensive form, Hallet realizes. On the other hand, Mr. John Heath of Australia, who has always given much consideration to the wider application of orthodontic treatment to all who need or require it, has recently said that by careful organization and systemized methods of treatment, a dentist may accept up to 100 new cases per year (or on a 46-week year a little over 2 new cases each week), though he does not commit himself as to the total number of current cases that he may have on his books at any one time.

Hallet investigated the number of cases an orthodontist may treat by enumerating on a time basis for individual operations the amount of time consumed in orthodontic treatment by an average case. By average, he visualizes the case that comes to surgery 9 times in the first year, 6 times in the second, and 4 times in the third. The result of this calculation is to indicate that an orthodontist may have about 760 cases upon his books and that, if he were starting an orthodontic practice, over the first four years he might absorb 4 new cases per week. Once, however, he has reached his total of 760 cases, then he must limit his new patients, in fairness to the other patients still undergoing treatment, and his ultimate absorption must be in the region of 2 new cases per week or 100 per year.

These estimates are only valid in so far as the problem is greater than the means of dealing with it. Postulating a three-year average period for active treatment of the specialist type case, and assuming an ideal of 400 specialists working under ideal conditions, then after the first three or four years we would have to consider only 10 per cent of three age groups. Two hundred to two hundred forty orthodontists might then conceivably keep the problem under control. However, as it will take many years to build up anything like this number of specialists, and as the demand for treatment and advice will undoubtedly grow enormously, and as all patients should be reviewed over a further period of at least three years (if only once per annum in the last two), and as it may be desirable for the average number of cases per orthodontist to be less than 750, then we should aim at 400 as the minimum required to keep malocclusion problems under control.

During the first year, the patient occupies more chair time than in any other year, and it must be noted that though it is not possible to take into account such factors as a patient changing to a more complicated appliance in the second year, or completely breaking a twin arch assembly by careless use, these things do happen and lengthen materially the time taken over a case. This should not be forgotten for it is bound to happen in an appreciable percentage of cases.

Hallet has postulated a minimum of 10 per cent of the school population as requiring advanced orthodontic treatment. If we take the most valuable

years for this treatment as being, say, 8 to 14 inclusive, that is to say, 7 age groups, we have out of three million children 300,000 to be treated. Taking 750 as a maximum number per orthodontist, we therefore need at least 400 full-time orthodontists to tackle the enormous problem in this country (England). This leaves a great deal of orthodontic work to be done which may very well, and even desirably, be carried out by the private practitioner, notably the school dentist, who is, or who should be, a child specialist in no mean sense. It is, then, the job of the general practitioner and the children's dentist to plan treatment of the child initially so that all incipient occlusal anomalies are recognized at the very earliest stage, and reported to the parents. They should be kept under skilled surveillance by regular reinspection until such time as they may be referred to the orthodontist; and in the meantime, it should not be considered outside the powers of such practitioners to deal with minor forms of malocclusion, such as, say, an instanding incisor. It is to that end that we are putting so much more emphasis in the schools upon the preventive side of children's dentistry, developing, we hope, occlusal consciousness in our young practitioners. There they see the dire results of early loss of deciduous teeth, the value of space maintainers, and so on. They are also able to observe the major anomalies treated by recognized methods. If the orthodontists are going to be so fully occupied with dealing with the 10 per cent who exhibit the grosser forms of malocclusion, they must have the full cooperation and understanding of the general practitioners. At the same time, the orthodontists must put their own house in order, so that their diagnoses are more accurate, their treatments more skillful, their "philosophies" less numerous, but more effective, and their results more stable! Here again we look to postgraduate training to produce such men, and it is encouraging to know that a start has already been made in this direction.

How are these orthodontists to bring their treatment to the children in the most effective way? There are at present several possible ways to be considered. Firstly, there is the private specialist practitioner who is outside the National Health Service. He can bring his services only to a limited number of patients who can afford his treatment, which invariably is expensive. He, therefore, cannot make any material contribution toward dealing with the great mass of work needed. Heath has recently suggested that in most countries only 2 per cent of those needing orthodontic treatment actually receive it. Specialist private practice of this nature of necessity postulate high expenses and, therefore, high fees. The general practitioner, too, is far too occupied with the many varied calls of private practice to devote more than a minute amount of his time to orthodontic work. His experience must naturally be very limited, especially during his first ten years in practice, and his skill and judgment must fall short of acceptable requirements. The general reluctance of most private practitioners to undertake any but the simplest of regulation cases is proof of this. Some use has been made in county areas of what might be termed the peripatetic orthodontist, who, by traveling around in a consultant capacity, deals with those cases selected for him at some prearranged session by the public dental officer. There are advantages and disadvantages to this scheme. But on the whole, the disadvantages outweigh the advantages. Though it is a great convenience for the orthodontist to be brought to the patient, it must not be forgotten that specialists' time is a very valuable commodity and many precious hours may be frittered away needlessly in the train or in the car, traveling between the headquarters and the dental centre. An advantage is that the experience and advice of the specialist is brought in a more intimate manner to the dental officer, who may thereby derive much information and instruction and often inspiration to specialize himself. His interest in the case is heightened and he is liable to

carry out adjustments more efficiently. However, one of the biggest drawbacks to this method of treatment is that the specialist can see his case only at very infrequent intervals and, owing to the duplication of records, at the dental centre and at headquarters, analysis of case results may be very difficult to make. On balance, therefore, he cannot accept this as a very satisfactory solution to the problem. There is another form of orthodontic advice to refer to at this point. There seems to be some possibility of specialists acting in a consultant capacity to other practitioners and receiving remuneration from them much in the way that the barrister derives his fee through his solicitors. There is a distinct danger here of diagnosis being made upon the casts of the patient's mouth alone, and this practice cannot be too strongly deprecated; even if reliable skiagrams are forwarded at the same time, there is still too much room for error. Orthodontic decisions involve so many variables and imponderables—not the least of these being the general quality of the hard dental tissues—something which it is very difficult to convey adequately upon the plaster cast for such a system to be satisfactory. Of what use is it to conserve molars of poor quality, remove premolars, only to lose the first permanent molars one by one between the ages of 15 and 20? Yet this can so easily happen. Nor do we wish to see the practice, as happens in America, of mechanics to the profession supplying appliances of doubtful design "for your difficult cases"!

No! In all cases, the patients must be present, together with the parents in person, for initial diagnosis.

The very first requisite, of course, is to train our dental surgeons in the schools in the wider field of dentistry, developing in all of them that sense of occlusal consciousness and power of automatic observation, so that every maxillary disharmony and each malocclusion is recognized, every missing tooth accounted for, and in all cases some definite action taken, even if it amounts to no more than pointing out the trouble to the parents, giving advice, and noting this on the treatment record card. The advice should not be to wait till 13 or 14—if, when the orthodontist does eventually see the child, he will say "it is now too late"! Suitable students can then go forward into the public dental services where they may, by the skill and excellence of their services, avoid many malocclusions and divert the worst forms in time to specialists. This brings us to the form of specialist advice for the large number of children who need and desire orthodontic treatment.

ORTHODONTIC CENTRES

This can best be done by setting up specially organized centres which would be under the control of the Ministry of Health and work for the private practitioner services and public dental officer alike. To cope at all with the work to be done, we need something like 400 specialists, and these would be distributed on a population basis, for instance, in a city of 60,000 child population.

It would be a self-contained unit especially for the purpose of giving orthodontic treatment and would be staffed by a team composed as follows: the Chief Orthodontist who would be in charge of the direction of the unit and be responsible directly to the Head of the Orthodontic Services at the Ministry. On his staff he would have his senior assistant and two other assistants, comprising 4 specialist orthodontists in all. Each would have surgery assistants and there would be at least 3 technicians needed for the purpose of making appliances and maintaining such things as the records and models. It is often forgotten what an important part of the orthodontic treatment is formed by these records. Record charts must be very carefully prepared

and as carefully stored. At the end of treatment, the series of charts, together with the diagrams, photographs, and all other relevant material, should be carefully reviewed in the light of past treatment. A frank judgment should be made of this and errors of judgment punctiliously recorded, so as to diminish the possibility of future similar errors. If in the past we had been a little less thrasonical about our good cases and a little more outspoken about our failures, the art of orthodontics would be in a more advanced state than it finds itself at present. All this valuable work is none the less a great time consumer, and some form of technical staff would be absolutely essential to make the collection of records automatic and therefore immune from the periodic breaks in continuity which inevitably occur when the filing of records is dependent upon the spare-time enthusiasm of the professional staff. The general technician could be trained to carry out the duties of photography in special cases and he could also prepare the charts of these cases in a suitable manner for photography and permanent collection. Trainees would very likely be public dental officers who are training to be specialists in children's dentistry, spending an adequate period at the centre (not less than six months) so as to acquaint themselves thoroughly with the type of work undertaken and methods of treatment, and thus broaden their outlook upon children's dentistry in general. They would assist in treatment, carrying out mouth procedures under supervision and also construct a number of appliances. They would assist in the examination of radiographs and in the delineation of diagrams. On their return to children's dentistry they could not fail to be better practitioners.

A fair proportion of them would derive such inspiration and show such promise as to forward on the recommendation of the Chief Orthodontist, to become full-time specialists themselves. It is to be hoped that the universities will come into the picture by setting the seal of professional competency upon them, offering postgraduate courses and diplomas in orthodontics. These diplomas must not be won easily and must, to be of value, demand previous specialist training extending over several years, otherwise they will mean nothing.

In the cities where dental schools are already established, a very close cooperation should be maintained between them and the orthodontic teams. One of the great difficulties of orthodontic teaching is that it suffers as a result of the great demand made upon the teachers by too much clinical work. It is not desirable that the Teaching Department should have to deal with every case sent to it. According to its size, there is needed an adequate supply of all the usual types of dental deformity according to present systems of classification, and also a number of those of obscure etiology and unpredictable prognosis. The teaching must not only be complete as to variety of types of malocclusion but also as to quality and thoroughness of diagnosis and of subsequent treatment. By thus restricting the volume of work, the standards of graduate comprehension of a case would be much higher and the teachers would be in a position to make sounder judgment upon, and more scientific conclusions from, their cases; and the child—that most important individual of all—would benefit enormously. But these are administrative details which can only be sketched broadly. Hallet's contention is that the most efficient and most effective way of bringing orthodontics to the school child is by the setting up, all over the country, of these specialist centres as an integral part of the General Health Service, staffed by specialist orthodontists working in full cooperation with our school dental services, private practitioners, and last, but by no means least, our dental schools.

Four hundred fully trained and fully occupied orthodontists could deal with the main part of the population's malocclusion.

The other attack upon this problem is the preventive one. Children's dentistry carried out in its fullest sense, as it should be, embraces diagnosis of incipient malocclusion, conservation of teeth at an early stage of decay (in itself an important malocclusion preventive for certain forms of irregularity), and the treatment bv the public dental officer of simpler forms of irregularity which may be easily corrected in a matter of a few months. This leaves the more difficult forms of treatment for the specialists. It is, of course, essential, for the full value of this preventive service to be obtained, that the school dental officer be not only *fully* trained, but also shall have done a postgraduate course in children's dentistry.

APPLICATION

1. The School Dental Service, accurate diagnosis, preventive methods and treatment of simple irregularities.
2. The specialist.

Specialists work most economically in small groups. They thus share technical (mechanical), radiographic, and other personnel. In especially difficult cases, there is the advantage of a second opinion being available—and, apart from this, discussion keeps the mind active and away from the dangers of becoming unreceptive to progress. In densely populated areas they should work in an orthodontic centre. In less densely populated areas, an orthodontist may have to work on his own at some convenient central place.

In sparsely populated areas, he may have to visit centres by car, but this is the most wasteful method, much time being lost traveling and assembling apparatus. He will still need a central laboratory and surgery of his own.

News and Notes

Central Section of the American Association of Orthodontists

The 1950 meeting of the Central Section of the American Association of Orthodontists will be held November 26, 27, and 28 at Cedar Rapids, Iowa.

Northeastern Society of Orthodontists

The fall meeting of the Northeastern Society of Orthodontists will be held at the Shoreham Hotel, Washington, D. C., Nov. 6 and 7, 1950.

Southern Society of Orthodontists

The twenty-sixth annual meeting of the Southern Society of Orthodontists will be held at the Sherry Frontenac Hotel, Greater Miami, Florida, Nov. 15, 16, and 17, 1950. Extensive plans and preparations are being made for this meeting. It will be held under the direction of President E. C. Lunsford, of Miami.

FRANK P. BOWYER, Secretary.

Southwestern Society of Orthodontists

The next meeting of the Southwestern Society of Orthodontists will be held Oct. 15, 16, 17, and 18, 1950, at Hotel Frances, Monroe, La.

Great Lakes Society of Orthodontists

The twenty-first annual meeting of the Great Lakes Society of Orthodontists will be held at Hotel Statler, Detroit, Mich., Nov. 19, 20, 21, and 22, 1950.

Orthodontic Alumni Society of Columbia University

The current officers of the Orthodontic Alumni Society of Columbia University are as follows:

President, Clinton B. Van Natta	630 Fifth Ave., New York, N. Y.
Vice-President, Irwin N. Tekulsky	168 West 86th St., New York, N. Y.
Treasurer, H. Milton Cooper	241 Main St., Hackensack, N. J.
Secretary, Irving Grenadier	888 Grand Concourse, New York, N. Y.

Children's Bureau, Federal Security Agency

Katherine F. Lenroot, Chief of the Children's Bureau, Federal Security Agency, announced the appointment of Miss Elma H. Ashton as Supervisor of training in the Bureau's Division of International Cooperation.

Working directly with Mrs. Elisabeth Shirley Enochs, Director of the Division, and in close cooperation with the various specialists of the Bureau, Miss Ashton will plan programs of training and observation for foreign specialists in child health and welfare who study in this country under the auspices of the Children's Bureau. The visitors come to the United States under programs arranged by the Department of State, Department of Defense, and the United Nations, as well as by other public and private agencies.

These foreign officials and professional workers are not only interested in the activities of the Children's Bureau, but also are eager to study a wide variety of services provided children by public and private agencies throughout the country, Miss Lenroot said. Last year more than 250 such specialists spent periods ranging from a few days to a year in the United States under the Bureau's auspices. While child specialists from other countries

have been coming to the Bureau for many years, virtually since it was established in 1912, their number has greatly increased since the war.

Miss Lenroot said that Miss Ashton brings to this position extensive experience in planning programs of study and observation for specialists from other countries, having served for three years as social affairs officer in charge of fellowships for the United Nations. Previously she had directed a similar training program for the United Nations Relief and Rehabilitation Administration.

Before her assocation with UNRRA, Miss Ashton was on the staff of the North Carolina Department of Public Welfare and later was a consultant in family and child welfare in the Bureau of Public Assistance of the Federal Security Agency. She has also worked with the American Red Cross and, more recently, with the New York Association for New Americans. She has taught in the Richmond, North Carolina, and Pennsylvania Schools of Social Work, and has had extensive experience as a psychiatric social worker in child guidance clinics in Harrisburg, Philadelphia, and Rochester, N. Y.

A graduate of the University of Richmond, with a master's degree in sociology from the University of Georgia, Miss Ashton holds a master's degree in social work from the University of Pennsylvania. She has also done graduate work at Harvard University and the University of North Carolina. She is the author of many articles on social work and is a member of a number of professional organizations.

Miss Ashton lives in Alexandria, Va.

American Dental Association

The dental nurse plan in New Zealand, operated by the government since 1921, has had a deplorable effect on the practice and development of children's dentistry in that nation, Dr. Allen O. Gruebbel, of Chicago, declared in a report released by the American Dental Association.

Dr. Gruebbel, secretary of the Association's Council on Dental Health, spent two months in New Zealand earlier this year surveying the system under which 85 per cent of New Zealand's 320,000 children, from 3 to 13, receive nearly all dental care from government-salaried dental nurses. The nurses, after limited training, fill, extract, and clean teeth of children.

Dr. Gruebbel was sent to New Zealand by the American Dental Association to evaluate the dental nurse plan after proposals were advanced for the establishment of a similar plan in the United States.

Dr. Gruebbel said he found that the prevalence of dental disease, particularly dental decay, is as high or higher in New Zealand at present than in any other country for which data have been reported and is "at least twice as high as in most areas in the United States."

The dental nurse system, as operated in New Zealand, he reported, has had "a deleterious effect on the scientific development of pedodontics (dentistry for children)."

"Dentistry for children, which many authorities believe to be the most important part of dental practice," he said, "is almost completely neglected by the dental profession in New Zealand, and until three years ago was not taught in the dental school."

This, he explained, resulted from the fact that under the scheme, dental care for children has been "relegated almost entirely to partly trained auxiliary personnel."

Dr. Gruebbel was sharply critical of the two-year training course provided dental nurses by the New Zealand government.

"Although the dental nurse is expected to provide a scientific health service, a considerable portion of which is of a surgical nature, she is given no scientific training, she is not encouraged to read scientific books or publications and she is not given an opportunity for continuing her dental education," he said.

The A.D.A. representative said he had found that scientific aspects of dental services were "deliberately excluded from the course of instruction in order that dental nurses will not develop a professional attitude."

Also contributing in large measure to the poor type of dental health service being provided children is the almost complete lack of technical supervision of the work of the dental nurse, Dr. Gruebbel said, pointing out that he found that dental officers often did not inspect the work of the nurses more frequently than once in six months.

He said that a child was supposed to be referred to a dentist if the dental nurse believed he required treatment beyond her scope, but added that "this practice is more often the exception than the rule." He continued:

"Young children need such expert services as surgical treatment of the pulp, preventive and corrective orthodontic care and preventive and corrective treatment for abnormal growth and development—services which few children in New Zealand now receive."

Inadequate and outdated equipment was also noted by Dr. Gruebbel. He said that satisfactory examinations and diagnoses were made impossible by the almost complete lack of x-ray equipment. He also found the use of questionable types of filling materials and equipment "symbolic of an era which modern dentistry has relegated to the past."

Dr. Gruebbel said that the government sponsorship of the scheme had given New Zealand parents a false sense of security regarding the dental health of their children, adding:

"The public cannot be expected to know dentistry's role in a complete health service so long as dental treatment for children is limited largely to filling, extracting and cleaning teeth."

Dr. Gruebbel also deplored the lack of research and measures designed to prevent dental disease.

"The approach has been to develop a large scale reparative service. No attempt of any consequence was made to reduce the size of the problem through research and prevention. The high incidence of dental disease and the high cost of the reparative service will remain unchanged until more emphasis is placed on research and prevention," he said.

Pointing out that the dental nurse plan has served as the basis for the development of a large-scale system of state dentistry in New Zealand, Dr. Gruebbel reported that a large number of dentists believe "that dental care controlled by the state eventually will lead to a serious deterioration of the quality of dental care as is now taking place in the field of medicine in New Zealand."

Air Force Seeking ASTP and V-12 Trained Dentists

Dentists who received all or part of their training under the Army Specialized Training Program (ASTP) or the Navy V-12 Program and who do not have commissions with other military services are eligible to receive commissions in the United States Air Force, Major General George Kennebeck, Chief of the United States Air Force Dental Service, announced.

The present law provides that dentists who volunteer for service will receive an extra $100 a month in addition to regular pay and allowances. They will be commissioned as first lieutenants unless their professional qualifications entitle them to a higher rank.

Application blanks or further information may be obtained upon written request from The Surgeon General, Headquarters, United States Air Force, Washington 25, D. C., or from the nearest Air Force base.

Notes of Interest

Dr. William C. Keller announces that since June 30, 1950, his New York City office has been consolidated with his Great Neck office at Wychwood Apartments, 28 Station Plaza, Great Neck, L. I., N. Y., practice limited to orthodontics exclusively.

Sherman J. LeMaster, D.D.S., announces the opening of his new office for the practice of dentistry at 8027 Clayton Road, Clayton 5, Mo.

Dr. Paul J. McKenna announces the opening of his offices October 2 at 14 Chestnut St., Springfield, Mass., practice limited to orthodontics exclusively.

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A People's Partnership

Community safeguards depend upon a united people. Especially in time of disaster efficient functioning is necessary if lives are to be saved and the injured and homeless given practical aid. That is why an organization such as the American National Red Cross is necessary. Haphazard planning won't do. People must know where to turn, how to coordinate their efforts to help.

The Red Cross was able to coordinate the services of civic groups in 1948 when more than 300 disasters struck in widely separated communities. Vanport, Ore., New Orleans, La., Coatesville, Ind., Greensboro, N. C., Bonne Terre, Mo., are many miles apart, but in each case the peculiar catastrophe that attacked these places was met by organized response.

All Red Cross work is divided between community volunteers and a full-time staff. Whether the work is educational and preventive, such as first aid, water safety, accident prevention, home nursing, nutrition; or remedial, such as aid to veterans, servicemen, and civilians, both hospitalized and able-bodied, the Red Cross counts on community cooperation.

The growing Red Cross National Blood Program particularly demonstrates the need for partnership that makes service possible. So far approximately 64,000 persons have offered to donate blood in this peacetime program, and blood has been distributed to more than 350 hospitals.

Let us continue to have faith in this people's partnership to the end that we will contribute our money, our time, and our moral support to make the 1950 Red Cross Fund campaign a success.

What is so right about this picture?

Is it that Dad's finally retired . . . the old alarm clock gagged for good?

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